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Predicting Backward

The word predict usually implies a future date, as to the occurrance of an event, such as an eclipse; but there is a form of prediction that relates to past events. For example, William Smith, that English surveyor who became "the father of geology" as a result of study of the rock strata at a coal mine, told the mine owner that if he would sink a shaft at a certain point to a certain depth he would strike the coal bed that had been displaced by a fault. He made a prediction of a future event, namely the finding of the lost coal bed, but it related to a geological event that had occurred ages before when the strata had cracked and had slid past one another. So the only futurity involved in his prediction related to the acts of men and not to the acts of nature. The natural event was ages old. The artificial event was yet to occur. When it did occur (by the sinking of the shaft) Smith was found to be right. His geological theory was confirmed.

A little thought shows that it is just as difficult to predict backward in the way used by geologists, as forward in the way used by astronomers. In both cases theory guides the actions of the predictor, and only correct theory guides him aright. The great job, then, is to devise correct theories by which to solve the mysteries of nature.

Fortunately nearly all scientific theories can be used to predict backward as well as forward. It is exceedingly important to appreciate this fact, for it furnishes a means by which to test any theory. For example, it is my theory that wage levels in each country vary directly with the per capita money in circulation in that country and with its velocity of circulation, or as the product of those two factors. If I had to wait until future changes in wage level had occured, in order to test the theory, I might not live long enough to satisfy myself that the theory is correct. But since per capita money statistics are available for each year for nearly 90 years, and since other statistics enable me to calculate velocity of circulation for nearly 60 years, I can test the theory closely for 60 years and roughly for 90 years back. Such a check shows the theory to be substantially in accord with the facts as to past wage levels, and thus I am justified in using the theory in forecasting probable future wage levels.

Simple as such a process of testing theories is, surprisingly few economic theories have been subjected to the test. Take, for instance, any theory that is commonly used by speculators in the stock market and you will look in vain for a careful test of it by the method of predicting backward. Is it A's theory that "tips" given by B are usually correct as to stock market movements, because of broker B's superior knowledge? A ready means is usually available for testing B's knowledge, by comparing all his past predictions with the subsequent events over a considerable number of years. Yet how many speculators ever use such a test? If many did, the game of fleecing the lambs would have long ceased to be profitable, for most of the lambs are either tip operators or believers in hunches.

In the field of science there is a vast mass of quantitative facts that remain to be explained and correlated. Theories, suggested by analogies between partly known classes of facts and well known classes of facts, can be readily devised by any engineer possessed of but slight originality. Then each theory can be put to the test by drawing conclusions from it and looking to see whether published facts agree with the conclusions. Where the facts are numerical, and where the theory is quantitative, a close agreement between fact and theory indicates probable correctness of the theory. And when the numerical facts cover a wide range of conditions, yet are in accord with the theory, the probability of the truth of the theories increases, finally reaching what amounts to certainty when the theory agrees quantitatively with a wide range of facts of a class that the theory was not originally designed to explain.

As an example of predicting backward, the writer published an article in the August issue of Engineering and Contracting entitled "The Inertial Theory of Motion and Gravitation," in which a theory of self-propulsion of moving bodies was used to deduce the Einstein formulas of relativity. The theory enabled the writer to deduce the three basic relativity formulas, and since precise predictions based on those formulas have been precisely verified, it follows that the writer's self-propulsive theory is probably correct.

Deductions of other established formulas from the self-propulsive theory will appear from time to time in future issues of Engineering and Contracting. Engineers who are interested in the derivation and testing of scientific theories should find such articles of value.

H. P. Gillette

Garden Hose Water

Data on Flow Given in The Colorado Engineer

By J. B. MARCELLUS
Chief Engineer, E. W. Marland Estate Development

How much water will flow through 50, 100 or 150 ft. of garden hose at various pressures? How much when there is a nozzle or sprinkling device on the end of the hose? How much when the hose end is open?

The Marland Development.—Ordinarily, the answer is not needed, but it was needed by the writer in the summer of 1926 in order to figure the size of pipe to be used for the development of an irrigation system on the 2,000-acre estate of E. W. Marland, President of the Marland Oil Company, at Ponca City, Okla. Since this estate eventually will become a garden with numerous varieties of shrubs, long vistas of grass and elaborate flower beds, the ordinary system of irrigation is impossible. The flood system is impracticable, not only because the topography will not permit it, but because it is not economical, as all the water for irrigation must be pumped to a height of about one hundred feet through one and a half miles of pipe. Some of the development, furthermore, will be Bermuda grass lawn, which requires only a little irrigation water, while adjacent will be a flower bed that will need water almost daily; and a large number of trees that are being transplanted will require water individually for the first three years.

Difficult as these varied features of the garden make irrigation, other types of development add complication. At present, for instance, five polo fields are being developed; and, in order to supply feed for the polo ponies, a part of the estate will remain in farm cultivation. On this tract five stables of sixty stalls each are now being built for the ponies; and nearby, for those who are to take care of the fields and ponies, is being developed a village for two hundred inhabitants, an up-to-date village with water and sewer facilities. On another part of the estate, a country club of five buildings is under way; and a country club, to be sure, means a golf course and floral surroundings.

That the garden hose will be important in this enterprise can readily be seen. A rather detailed plan for one-half section (320) acres showed the need of about 50 hose. Though the rainfall in this vicinity is about 40 in. a year, it is so unequally distributed during the growing season that an elaborate garden development is impossible without irrigation of some kind. In August, 1926, for instance, one 9-acre polo field used 105,650 cu. ft. of water. In a single unit, of course, the garden hose is a small item in a water works. If a single garden hose discharges 7.5 gal. per minute, and there are two millions in use for one hour, the quantity of water discharged amounts to 950 million gallons. We usually consider the use of water for sprinkling as part of the average daily 100 gal. per capita per year consumption, and the annual peak demand comes during July and August. In the Marland development, no such per capita average could be used.

The Tests.—Tests were made in August and September, 1926, to determine the amount of water discharged by the ordinary garden hose. These tests are not complete by any means, but they give an indication of the amount of water to be used for this development. The tests were made under field conditions, and were made as time permitted. The rodmen of the field parties were occasionaly used as observers, and no exacting refinements were made.

The apparatus was a pressure gauge, an ordinary ¾-in. meter, a ¾-in. valve, 500 ft. of ¾-in. hose in 50-ft. lengths, an ordinary garden hose nozzle, and a revolving spray. The meter, pressure gauge and valve were connected together on a board which could be easily carried. This apparatus was attached by a short piece of ¾-in. hose to a ¾-in. riser, which was attached to a 1-in. supply line. The apparatus was attached where the men attached a hose to water surrounding shrubbery. In some cases, a man was actually watering flowers, trees, etc., on the discharge end of the hose while the tests were being made. Altogether, slightly more than 300 runs were made.

The process involved (1) the measure of pressure before the valve in the hose adjacent to the meter was opened, (2) the pressure while the water was running, (3) the initial meter reading, (4) the final meter reading, (5) the cubic feet passed, (6) the initial time, (7) the final time, (8) the minutes, (9) the gallons per minute, (10) the length of hose, and (11) the hose outlet—whether open, with nozzle attached, or with whirling spray. The tests (runs) were from 5 to 30 minutes long. The running pressure, or the pressure when the water was flowing, was from 10 to 50 lb. This pressure was regulated by the valve at the meter. The pressure in feed line varied from 40 to 80 lb., depending upon the number of other users on the line. On Sunday, when some of the tests were made and no men were watering, the feed line pressure was 80 lb. This feed line was connected to the Ponca City water system. A few tests were made from a hydrant on a 2-in. feed line. The hose was laid on fairly level ground. Some tests were made to see if there was any difference in discharge if the hose was laid straight or crooked; but very little difference could be detected so long as the hose was not kinked.

Summary of 300 Tests.—Table I is a summary of the three hundred or more tests. It is used as a basis for determining the size of pipe on this development. Only hose lengths in multiples of 50 ft., up to 150 ft., are given in this table, as this is the maximum length that is expected to be used on this work. A length of more than 150 ft. is very difficult for a man to handle, and it is more economical to move the hose to a nearer hydrant.

Table I—Garden Hose Data

	50 ft. hose			100 ft. hose			150 ft. hose		
Pressure	Open	W.S.	Nozzle	Open	W.S.	Nozzle	Open	W.S.	Nozzle
10	3.68	3.36	2.51	2.72	2.10	1.83	1.94	1.91	1.75
15	4.34	3.52	2.89	3.49	2.72	2.36	2.45	2.27	1.98
20	4.94	4.16	3.74	4.57	3.16	2.74	2.93	2.69	2.48
25	5.61	4.91	4.11	4.78	3.74	3.14	3.68	3.05	2.65
30	6.19	5.24	4.56	5.19	4.04	3.36	3.97	3.53	3.08
35	6.73	5.93	4.96	5.41	4.30	3.74	4.36	3.82	3.42
40	7.33	6.35	5.36	5.50	4.53	4.11	4.70	4.26	3.66
45	7.85	6.56	5.71	5.82	5.16	4.49	4.92	4.56	3.89
50	8.52	6.82	6.09	6.73	5.40	4.71	5.05	4.78	4.20
55	.....	7.05	6.37	7.03	5.93	4.97	5.96	5.11	4.41

W.S.—Whirling Spray on end of hose.
Pressure when water is running.
Quantities given in gallons per minute.

As is indicated, these tests were made at odd times under field conditions, but the results give an indication of the quantity of water that may be discharged through a ¾-in. garden hose in actual use.

Water Bills

Some interesting information on handling consumers accounts was brought out by the superintendents' question box at the Chicago convention of the American Water Works Association. In answer to the question: "Have you tried continuous billing? Do you prefer it?" 78 replies were received. Of these 35 stated they had tried continuous billing and 43 stated that they have not tried it. Of the 35 that had tried it, 32 preferred it, 2 were noncommital and one didn't prefer it.

The question "Are the Bills Collected by the Treasury Department of the city or by the Water Department," brought 83 replies. In 12 cities bills are collected by the treasury department, in 47 cities bills are collected by the water department. The other 24 replies were from private water companies.

The question "Are Bills Mailed or Delivered in Person," brought 77 replies. In 50 cities bills are mailed; in 19 cities bills are delivered in person. In 8 cities some are delivered by mail and some in person. Of the cities mailing bills, 19 said it was cheaper to mail them than to deliver them in preson; 7 said it was more convenient; 13 that it gave better results and 11 did not give any reason at all for mailing them. Of the 19 cities, where the bills are delivered in person, 11 thought it cheaper to deliver the bills in person; 3 thought it more convenient; 3 thought it gave better results and 3 gave no reason.

Laying Sewer Through Peat Bog

How New England Contractor Handled Difficult Clay Pipe Job With Very Simple and Economical Methods

By J. O. MILLER

Economy and excellence have been combined on the Faxon Park drain job in Quincy, Mass., by cooperation of engineer and contractor and the adapting of old tools to a new type of work.

Mr. E. J. Sandberg has the contract for laying this 24-in. vitrified clay pipe storm sewer through a peat bog full of prehistoric roots and subsurface stumps.

Superintendent of Sewers McKenzie has set forth specifications and plans which have enabled the contractor to use very simple and effective methods of work on the job.

The drain is pile-supported and, as a few more stumps made little difference, the piles were driven ahead of excavation (Fig. 1).

Ground water was encountered just below the surface and pumping was necessary until backfilling was completed.

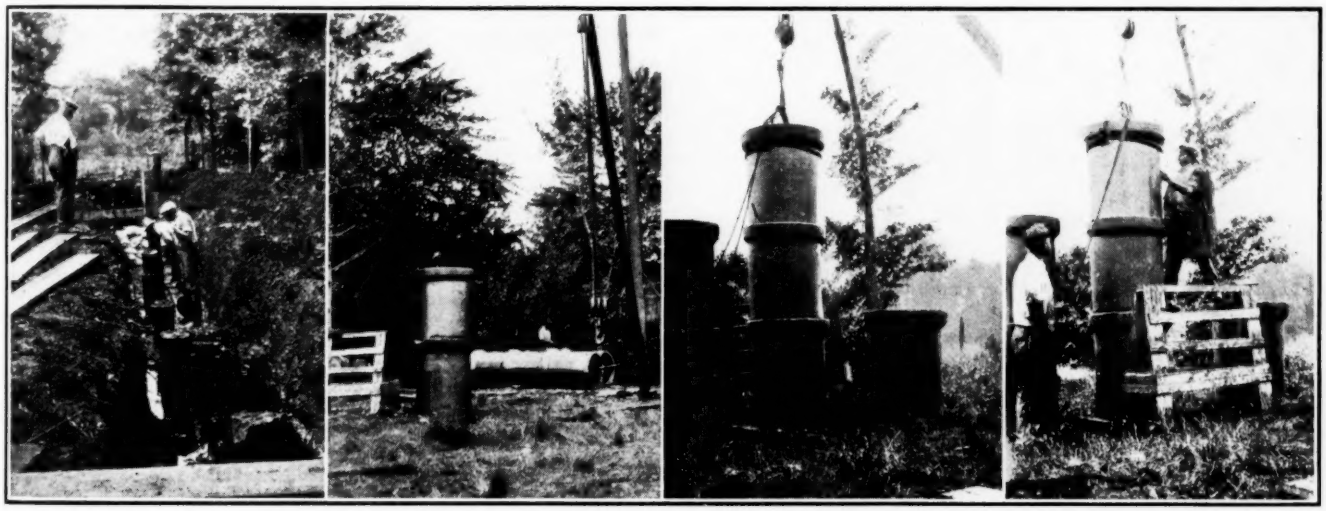
After the excavation was completed and piles cut off in a given section the required timber grillage was placed on the piling and transverse cradles placed on 3-ft. centers to receive the pipe.

Jointing Method.—As this piece of work was designed to act as a storm sewer at normal tide levels and as a storage or impounding reservoir during excessive high tides, infiltration was doubly undesirable. Hence the specifying of "asphaltic compound joints." "Sewer-seal" or "Tatonite" was used on this work. "Sewer-seal," "GK," and "Jointite" being the commonly accepted compounds for sewer pipe jointing in New England.

The location is partly in woods and partly in clearing, but it was practically impossible to run a road parallel and adjacent to the line of excavation. This made it necessary to deliver the 3-ft. lengths of 24-in. clay pipe (weight about 450 lb.) at points on the ditch that could be reached by trucks.

At these points the contractor set up his pipe in 2-pipe or 3-pipe units and rolled or swung them to the required place on the work.

Cutting Handling Cost.—When the woods approached too closely the 2-pipe units were used and after being rolled



Left to Right—Fig. 1—Excavation After Driving Piles. Fig. 2—Stiff-Leg and Tackle. Fig. 3—Progressive Jointing of Pipe. Fig. 4—Caulking Joints

Left to Right—Fig. 5—Laying Down a 3-Pipe Unit. Fig. 6—Pipe Jointed, Ready to Move Them. Fig. 7—Two Men Moving About 1,300 Lb. of Pipe. Fig. 8—Ready to Lower Away

to place (either over the ground surface or on sills) were laid in place, usually with a tripod and tackle (Fig. 11). However, if a suitably large tree was at hand the mast of a light stiff-leg derrick outfit was lashed to it and this used instead of the tripod.

Fig. 9—Upper—Sling for Laying in Ditch. Fig. 10—Center—Tripod for Use in the Woods. Fig. 11—Lower—Showing Use of 2-Pipe and 3-Pipe Units

After the derrick was erected by the above method, or by guy wires in the open, all the pipe laying, jointing, moving, etc., was handled by two men. And they also operated the pumps.

The method was simple. After unloading from the trucks the first pipe were set solidly, spigot end down, with care being taken to get the axis as near vertical as possible without "fussing" over it. Then the second lengths (and in turn the third lengths) were lifted by the derrick, with one man on the winch, and lowered into place (Fig. 3). The winch operator used a stick brake on the main pinion and lowered so slowly that his helper centered the spigot without difficulty (Fig. 7).

Caulking.—For caulking a single strand of dry "jute" was used and then the annular space filled with the hot asphaltic compound. The caulking and pouring of the joint between the second and third lengths necessitated the use of a light trestle about 4 ft. high (Fig. 4).

In heating the compound the contractor used an ordinary hemispherical cast iron kettle of about 15 gal. capacity. Ordinarily only about 100 lb. (say 8 gal.) of compound were heated, melted down, as this was sufficient for jointing 10 or 12 pipe and would be used rapidly enough to prevent settlement of the inert material which might occur from prolonged heating and carelessness in stirring. The compound was ladled from the large kettle into a smaller "scuttle" shaped pouring bucket which held about 20 lb. This amount gave 100 per cent as a factor of safety should the gasket slip on pouring any joint.

Handling the Units.—After the joints had cooled the multiple units were lifted (by one man on the winch) (Fig. 5), swung to the bank of the trench and laid down. Then they were either rolled to their location (Figs. 10-11) to be placed by the tripod and falls or reslung horizontally to be placed by the derrick (Figs. 8-9).

As the pipe unit was lowered into the ditch it fitted into the transverse cradles placed to line and grade and the spigot was centered in the preceding bell and brought "home" as the unit was placed.

Caulking in Trench.—The required "jute" was then caulked into the annular space and the gasket or "snake-runner" placed to retain the jointing compound.

This "snake-runner" is clamped and held in place by a very well contrived device. It is cut to the required length and the ends fastened to the halves of an ordinary wood vise or carpenter's clamp by staples and bolts (Figs. 12-13). The use of the regular screws enables the operator to adjust the square, braided, asbestos gasket as he desires. It is, of course, kept thoroughly wet and is coated with clean clay when pouring the joint. Clay is moulded to make the "gate" at the top.

Pipe Slings.—This work was carried on during the summer months and even during the most marked heat, no stretching, opening or other distortion of the joints was noticed by the inspector on the job.

When hoisting the 3-pipe unit vertically it was the custom to use slings on the two upper lengths (Fig. 5) and when lifting horizontally, slings on the end lengths (Figs. 8-9).

Inspection of several hundred feet laid at the time of the writer's visit revealed no visible leaks in the joints.

Fig. 12, Upper—The "Snake-Runner" Clamped in Place. Fig. 13, Center—This Is a Field Repair Method Worth Remembering. Losing One Screw Doesn't Bother Much. Fig. 14, Lower—Mr. Sandberg Tells His Son—"Good Work"

Bituminous Penetration Pavement

Design Features and Methods of Construction Discussed in Paper Presented at Annual Convention of American Association of State Highway Officials

By E. C. WELDEN
State Highway Department of Connecticut

In the design and construction of bituminous pavements, may be included all classes of work in which bitumen in the form of asphalt or tar is used as an integral part of the pavement. Roughly they may be divided into two classes: First, those composed of mechanical mixtures, which in nearly all cases are laid hot and in which class is included sheet asphalt, topeka, and many of the patented pavements, such as warrenite, bitulithic, amiesite and others; second, bituminous macadam, in which the voids between the stone of the wearing course are filled with bituminous binder. Space will not permit of a lengthy discussion of all of the various types. Therefore, bituminous macadam, because of its adaptability, economy, simplicity and the availability of materials entering into its construction, will form the basis of this paper.

In the design of the pavement, whether it be of bituminous macadam or of some other type, the character and intensity of traffic should be given the most careful attention. A design that may be adequate and economical for one locality may prove an utter failure when built in locations and under conditions not adapted to its use.

Pavements, like structures, "are designed for a specific purpose," and every engineer whose duty it is to supervise their design should study, not only the probable loadings to which they will be subjected, but must also have an understanding of the internal forces resulting from these loads.

In the design of a bituminous macadam pavement, it should be borne in mind that there is little inherent stability in the pavement property. This fact necessitates intelligent design and careful construction of the foundation upon which it is to be placed, for it is in the foundation that the essentials governing the success or failure of the work will often be noted.

Foundation Course.—The carrying capacity of the pavement is influenced to a great extent by the moisture-content and character of the subsoil beneath. With very few exceptions this capacity is increased as the moisture content in the subsoil is decreased, and for this reason it is essential that adequate drainage structures be provided to reduce to a minimum the amount of free water beneath the pavement. This usually can be successfully accomplished by the use of standard drains placed on one or both sides of the road, as may be required.

In the case of very retentive soils not easily drained, increased stability may be obtained by the use of a layer of sandy gravel, cinders, or slag, spread over the surface to a depth of 6 in. or more. This treatment is not ordinarily expensive in localities where these materials are available and has proved very effective on roads that are not subjected to the frequent use of heavily loaded trucks.

There are, however, many locations where it will be necessary, because of local conditions and the intensity of traffic, to provide foundations of greater strength and thickness. This is usually accomplished by a layer of field stone broken and placed by hand, or by the use of coarsely crushed stone either from a local or commercial crushing plant.

Field stone when available is usually the more economical. The depth of this course will depend to a great extent on the character of the subsoil and the sizes of stone used. It is largely a matter of judgment on the part of the engineer, but will ordinarily range from 6 to 12 in. in depth.

This course, after being thoroughly rolled, should be filled with coarse sand or fine gravel and again rolled until firmly compacted. To foundations of this nature should be added a layer of crushed stone 2 to 3 in. in depth. This stone should be carefully spread to the required grade, rolled and filled to provide a uniform surface for the top course.

There are many sections where it is possible to secure gravel suitable for a base course from local deposits with a considerable saving in cost over the use of broken stone. A well graded gravel gives excellent results and has the advantage of presenting a more uniform surface for the use of the public during the construction of the road. It is good practice to carry the foundation course under the shoulders to the gutter line, thus insuring better drainage and greater stability for the pavement.

It will not always be found necessary to place a foundation course under bituminous pavements, there being many localities where the soil is of a permeable nature with sufficient bearing power to support the pavement and the super-imposed loads. If, however, there is any doubt as to its necessity, it is better to err on the side of safety.

Base Course.—In general, the design and construction of the base course is essentially the same throughout the eastern states. It usually consists of a compacted layer of crushed stone, 5 to 7 in. in depth, laid and rolled in two courses. The sizes of the stone used vary somewhat, depending upon its source. If obtained from a commercial quarry, well graded stone passing a 3-in. ring and retained on a 1½ ring will give very satisfactory results. If the stone is crushed on the job, greater latitude in the sizes used is not considered objectionable, although great care should be taken to prevent the smaller sizes forming in pockets due to segregation.

While the quality of the stone used in the base course does not need to be selected with the same care as should be exercised when choosing material for the top course, it should, however, be reasonably hard and structurally sound. Stone having a percent of wear of not more than 5 and that when crushed produces few flat or elongated pieces, may be safely used even in roads that will be subjected to reasonably heavy traffic. It is to be inferred that by heavy traffic is meant the gross weight per unit load rather than the number of units passing over the road.

Sand that is well graded and free from loam is considered an ideal filler for the base. Screenings are often used for this purpose and when obtained from rock of a low cementing value will usually prove satisfactory. Screenings obtained from trap rock and some of the lime stones are not considered equal to sand as a filler because of their impervious nature when compacted with the stone of the base course. The high cementing quality of this type of filler produces a hard, unyielding surface preventing any mechanical bond between the base and top course.

It has long been realized, both in the rigid and elastic types of pavement, that the edges constitute a point of weakness. To overcome this and provide greater lateral stability for the top course, it is recommended that the base course be constructed 6 in. wider on either side than the penetrated portion of the pavement. While this has not been the standard practice in the east and, at first thought, may seem an unnecessary expense, it is felt that this method of protecting the edges of the pavement from wear and settlement justifies the small additional cost. Not only will this additional material serve

as a support for the top but will be found equally valuable in strengthening the shoulders, thus affording greater resistance to traffic when shoulders are used by passing machines or as a parking space.

Top Course.—In considering the top course, it is highly important that certain factors be taken into consideration, for in this course are to be found many of the faults, as well as the good qualities, of this type of pavement. It is also here that are found the greatest differences in construction practice among the various states and municipalities. Among these differences may be mentioned the depth, physical qualities, and sizes of stone used; the quantity and character of bitumen; and the methods employed in incorporating these materials.

These differences of opinion have tended to produce anything but uniform results in the locations where these pavements have been most commonly used. It may, however, be noted that at the present time there seems to be a tendency to greater uniformity in many of the details so necessary in securing the best results in pavements of this type.

Size and Quality of Stone.—Without doubt the best results will be obtained through the use of crushed stone of large and uniform size. This size may vary somewhat with the hardness of the stone used. In the case of trap or other rocks showing a percent of wear not greater than 3, ideal sizes will be obtained by the use of stone passing a 2½-in. circular screen and retained on a 1½-in. circular screen.

The key stone recommended for use after the first application of the binder material should be the ordinary commercial ¾-in. size, obtained from passing through a 1-in. screen and retained on a ⅝-in. screen. For the second application, cover stone ranging in size from ⅝-in. to ⅜-in. is favored.

While the use of small stone ranging in size from ¼-in. to ¾-in. is sometimes specified to follow each application of bitumen, it is felt that better results will be obtained by using as key stone the commercial ¾-in. sizes previously mentioned, following the first application, because of the greater mechanical bond obtained.

Only stone that will show a per cent of wear not greater than 3 and a toughness of not less than 12 should be used in bituminous pavements that are to be subjected to exacting traffic conditions. Hard, tough rock that does not fracture or crumble under the roller can be more readily compacted to form a smooth interlocking top with uniform voids, than will be the case if softer or less uniform stone is used.

Uniformity of voids is of vital importance in securing an even penetration of bitumen. Pockets of small stone occurring either as a result of being crushed under the roller or from the use of stone improperly graded are productive of results detrimental to the smoothness of the pavement.

The stone for this course should consist of only clean, tough, durable fragments, free from flat or elongated pieces. It should be carefully and uniformly spread, after which it should be compacted by rolling until the fragments are keyed together to form a surface that will show little displacement under the roller.

Thorough Rolling Important.—The importance of thoroughly rolling the top course before applying the bitumen can not be too strongly emphasized. Too often this feature of the work is slighted.

The use of a 3-wheel roller weighing not less than 10 tons is recommended for this work as well as for all other work where a roller is specified.

While considering the adaptability of stone for the penetrated portion of the pavement, it may be well to call attention at this time to a condition sometimes present in stone that otherwise meets all the necessary requirements. I refer to the slippery or greasy character of some rocks that prevent a proper adhesion of the bitumious binder. This is a serious fault that will result in an inferior pavement if not complete failure. For the same reason, stone that is coated with dust or dirt is also objectionable and its use should be avoided.

In locations where it is not possible to secure ideal stone at a reasonable cost, inferior rock has often been used with very successful results in roads that carry only light traffic. When using the softer grades of stone, relatively larger sizes than those specified for trap or its equivalent are preferable.

After the stone has been carefully spread, it should be rolled only enough to secure a uniform cross section, since continued rolling will tend to crush the fragments, thus preventing a proper distribution of the bitumen. While too much rolling before applying the bitumen may be harmful, there is no question regarding the necessity of thorough and continuous rolling after the surface has been completed. If the weather is warm and the binder is in a more or less plastic condition, this rolling may be continued with beneficial results for several days.

Depth of Penetration Course.—The depth of the penetration course as ordinarily laid, varies from 2 in. to 3 in. in thickness depending to a great extent on the sizes of stone used and the amount of bitumen desired per square yard. Obviously, the depth should be increased as the maximum size of stone to be used is increased. Ordinarily, it is safe to consider that the minimum depth should be equal to the diameter of the screen through which the stone passes.

I feel that the best results will be obtained with the use of hard, tough stone ranging in size from 2½ in. to 1½ in. where a compacted depth of 2½ in. is desired for the top course. Care should be taken to use only enough stone to secure the desired depth after rolling. Too great a depth of stone will produce a surface that will not be properly filled by the bitumen, while insufficient stone will cause a condition in which the excess bitumen will tend to produce a surface that becomes wavy and picks up under traffic during hot weather.

After applying the bitumen and while it is still hot, key stone should be spread over the surface in sufficient quantity to fill the voids. Any excess stone that is not embedded in the bitumen after the surface has been rolled should be removed by the use of hand or power brooms before the second application. The condition of the surface before this application is important in its relation to the completed pavement. A surface that is covered with loose stone is not readily penetrated, resulting in a blanket of bitumen and cover stone. This condition does not give the most satisfactory service under heavy traffic.

Ideal Surface Should Be Smooth and Tight.—I am of the opinion that the ideal surface should be smooth and tight, presenting a mosaic appearance in which the upper surfaces of the larger stone are exposed to the action of traffic. Although this condition requires the use of high grade rock, I feel that the results attending its use justify its selection for all pavements of this type that are to carry heavy traffic. The mosaic condition referred to is not obtained until the road has been subjected to traffic from three to four years.

The amount of cover stone used on the second application of bitumen will depend to some extent on the temperature of the air and of the materials when the work is done. During the summer considerable more stone can be rolled into the surface than will be possible during fall construction. This stone should be uniformly spread. If bunches form, they should be removed by the use of brooms.

Key stone and cover stone should both be spread parallel with the center line of the road. This is not only productive of a better riding surface but will materially assist in preventing the voids becoming filled in the opposite half of the road when only a portion of the width is being penetrated at one time.

Practice has shown that with trap or an equally heavy stone, the amounts per square yard of surface for a 2½-in. top course are as follows: Coarse stone, 240 lb.; key stone, 50 lb.; cover stone, 38 lb. During the fall of the year the amount of cover stone that can be used to advantage will not exceed 25 to 30 lb. Anything in excess of this amount will be ground up or thrown to the sides of the road by passing traffic.

Bituminous Binder Material.—During the earlier years of the construction of this type of pavement, tar as a bitu-

minous binder was probably more commonly used than now. Present day practice seems to favor the use of asphalt, although tar with the softer stone has proved very successful on pavements where the travel is light.

In early construction work the bitumen was poured by hand from pots or applied by the use of a hose attached to a distributor tank. These crude methods have now been replaced by the use of motor driven pressure distributors equipped with heating units and insulated tanks. Perfected machinery has greatly increased the speed and quality of this part of the work.

There has been and still is a considerable variation in the amount and hardness of the binder used by various states. At the present time the general practice seems to favor the use of asphalts with a penetration between 85 and 100 for use in roads that are to carry heavy traffic. Asphalt having a penetration between 100 and 120 is commonly used in some locations where traffic is light and during late fall construction. The use of too soft an asphalt tends to promote corrugations in the surface of the pavement and to increase maintenance costs.

Should penetration construction be desired for locations where traffic is concentrated and extremely heavy, asphalt with a penetration between 60 and 70 is recommended. Binder of such low penetration will show little displacement under traffic even in the warmest weather, nor will it be affected by low temperature if travel is sufficiently heavy to develop the surfacing process before winter.

The amount of bitumen used should vary with the depth of stone in the top course. It may be generally stated that this amount will be equal in gallons per square yard at 60° F. to the depth in inches of the stone to be penetrated. In case of a 2½-in. top constructed of the sizes of stone specified, the use of 1¾ gal. of tar or asphalt per square yard for the first application is recommended, while for the second application ¾ gal. is sufficient. It should be borne in mind that a correction must be made in the yardage that will be covered with bitumen that has been heated, because of the expansion that takes place.

The binder material in the form of tar or asphalt should be heated to not less than 275° F. nor more than 350° F. for asphalt, and not less than 225° F. nor more than 300° F. in the case of tar.

If stone passing a 3-in. circular opening is used in the top course laid as suggested to a depth of 3 in., the amount of binder used should be increased to 2 gal. and 1 gal. for the first and second application respectively. These amounts of bitumen are too liberal where stone soft enough to break up under the roller is being used.

Effect of Seasonal Changes.—Any paper dealing with the construction of bituminous macadam pavements would not be complete without a word in regard to the effect of seasonal changes in the results obtained. Because of the great variation in climatic conditions between different states, no rule as to when top course construction should cease can be reasonably stated.

The surfacing process resulting from the action of heat and traffic can only be effective while the temperature is still warm enough to soften the binder material. A pavement that is laid during cold weather and opened to traffic has little chance of developing a smooth surface. The binder material is inclined to be brittle and the cover stones are easily dislodged by traffic and swept to the sides of the road carrying with them in many cases small particles of the bitumen. Surfaces that have lost much of the cover stone and some of the bitumen ravel easily and are not easily repaired. Late surfacing work should be avoided whenever possible. If it must be done and opened to traffic the surface should be kept well covered with a blanket of coarse sand during the winter months.

Conclusions.—It would be foolish to assume that any one type of pavement will give the best results under all conditions; to do so would be to court disaster and the necessity for the reconstruction of many projects.

Unstable subsoil conditions prevailing over long sections of road that can not be adequately drained offer very little support for a pavement of the penetration type. While the construction of elaborate drainage structures and the formation with permeable materials of a foundation course will to a great extent overcome the difficulty, it is felt that greater efficiency and economy may be obtained by the selection of some other type of pavement.

While it is true that careful consideration must be given to the selection of suitable materials and to the details of construction to secure the most successful results, these requirements are in no way peculiar to penetration macadam since "the same essentials are equally important in the construction of every other type."

Probably more has been learned from practice than from theory regarding the limitations of these pavements. Experience has shown that even when subjected to heavy truck traffic, bituminous macadam pavements that were properly constructed have functioned successfully for long periods of time with surprisingly low maintenance costs. It is no doubt true that many of the failures charged to this type of pavement are the result of improper design, unsuitable materials, or faulty construction, rather than to the depreciating action of traffic.

Pavements of this type have been designed to give economical and satisfactory results even though subjected to varying degrees of traffic. One has but to ride over some of the heavily traveled trunk line highways in the east, on which this type of pavement has been laid, to appreciate the traffic resisting qualities of bituminous macadam when designed to meet the maximum legal loads allowed by law, while their adaptability for use on residential streets is shown by the millions of square yards that have been laid in cities and villages throughout the country.

The following suggestions are noted for consideration in connection with the design and construction of bituminous macadam pavements:

1. The base course should be compact, tight, unyielding to the greatest degree, and rolled to a smooth uniform surface, since any unevenness in this course is almost sure to show up in the surface.

2. The thickness of the foundation depends largely on subsoil conditions and traffic requirements.

3. The selection of mineral aggregates and binder material of a character suitable to meet the requirements for the type of work to be done.

4. The discouragement wherever possible of late construction work on the penetration course.

5. Careful construction methods directed by engineers experienced in this type of work.

Resistance to wear, impact and abrasion, together with its adaptability for speedy construction and easy maintenance should increase the popularity and use of bituminous macadam pavements.

Texas Commission Has New Accounting System

Following approval by the Texas State Highway Commission of plans and surveys made by H. L. Washburn, auditor of Harris County and designer of a new system of accounting for the Highway Department, work has started on the inauguration of the system.

A certified public accountant has been employed to install the system under the direction of Washburn, and estimates are that the work will be completed in sixty days. The entire present system will be changed and practically abolished, and the new method will be built around a central unit to have complete charge over accounts in all divisions of the work.

Failure of the department to have a system whereby a full check could be kept on outstanding indebtedness and the amount of income due is said to be the main reason why further Federal aid was withheld from Texas about six months ago. Members of the commission declare fully justifiable accounts are continually coming to their attention that were incurred months ago, but nothing was known of them because of the muddled system.

Water Plant Records

System Used at Spartanburg, S. C., Described in Paper Presented Before North Carolina Section Am. W. W. Assoc.

By J. K. MARQUIS

Engineer in Charge Spartanburg Water Plant, Spartanburg, S. C.

In the operation of any water plant it is very essential that adequate records be kept. The various amount of data that is tabulated daily in the plant should be arranged and filed away for future reference. It is needless to stress the importance of plant records for their importance is recognized by all wide awake plant operators and superintendents.

We all know, that in the adoption of any system of record keeping that it should meet with the requirements in question rather than plants in general. This point, I think is recognized by water works employees and officials.

Again, the system adopted should be as simple as possible consistent with the data to be recorded. Therefore, we may classify a record system as follows: It must be simple, reducing the time element to a minimum; it should furnish a complete record of all essential data that might be of importance in the future. I shall try to outline in this paper the system of recording as adopted by the Spartanburg Water Plant.

Outline of Recording System.—The Spartanburg plant was completed in the month of May, 1926, and it consists of a hydro-electric plant in conjunction with the pumping and filter plants. The hydro-electric plant furnishes the power for pumping and any additional power is sold to the local power company at our switchboard. However, I shall make the pumping and filter plant records the major part of this paper.

Our system may be divided into three general heads, namely: records of plant operation; records of maintenance, repairs and supplies; records of the cost of purifying the water and pumping it to the reservoir. I shall only treat of the records of plant operation. These records I have classified under the following heads, pumping plant reports, filter plant reports, records of bacterial examination, automatic records, a general office record, and graphical records. The first three of these reports are filled out by the operators, leaving the general office record and the graphical records to be filled out by myself.

Pumping Plant Report.—The pumping plant report, a reproduction of which is shown in Fig. 1, is made daily, giving the following information. Spacing is provided for the operation of the generators, the time they were started and the time they were stopped, total hour run, the load carried, and the kilowatt hour output. Likewise, spacing is provided for the power sold, used or purchased. Enough blank spaces are provided for any change overs during the day. All non-essential data such as generator and exciter bus voltages and amperage have been eliminated. As the voltage and amperage is a constant for any one given condition, I think it to be a waste of time to record them daily. Spacings are provided for the operation of the pumps similar to those for the generators. Provision is also made for the Venturi meter readings, the readings being taken at midnight. The height of the water in the reservoir which is recorded by a Gurley recorder, is also recorded on this report at midnight. The consumption of water in the city is determined by the difference of water level in the reservoir together with the pumpage. The blank lines near the bottom of this report are for the signatures of the operators, the time they came on duty and the time they were relieved. The size of this report is the same as that of a stand-

Fig. 1

SPARTANBURG WATER WORKS

POWER PLANT DAILY REPORT Date April 6 1927

GENERATORS

NO.	TIME ON	TIME OFF	HOURS RUN	LOAD CARRIED	METER READING MIDNIGHT	METER READING LAST NIGHT	ELECTRICAL OUTPUT IN KILOWATTS	TOTAL KILOWATTS
1	12:00	12:00	24	520	1980	1877	10300	10300

POWER SOLD

NO.	TIME ON	TIME OFF	HOURS RUN	LOAD CARRIED	METER READING MIDNIGHT	METER READING LAST NIGHT	ELECTRICAL OUTPUT IN KILOWATTS	TOTAL KILOWATTS
1	7 00 PM	11 00 PM	16	300	1445	1439	6000	6000

POWER PURCHASED

TIME ON	TIME OFF	HOURS USED	LOAD CARRIED	METER READING MIDNIGHT	METER READING LAST NIGHT	TOTAL KILOWATTS
				0017	0017	

Power Used for Pumping 4300 K. W. Water Released Through Wheels 67,400,000 Gals.

PUMPS

NO.	TIME ON	TIME OFF	HOURS RUN	NO.	TIME ON	TIME OFF	HOURS RUN	TOTAL HOURS RUN
1	10 00 PM	12 00 M	2:00	B	12:00	3 20 PM	15:20	17:20

Venturi Reading Midnight 95588 Gals. Height Reservoir Midnight 8.4 Feet
Venturi Reading Last Night 95268 Gals. Height Reservoir Last Night 9.2 Feet
Total Pumpage 3,200,000 Gals.
Water Used in Spartanburg 3,160,000 Gallons

OPERATORS

NAME	TIME ON	TIME OFF
B. B. Tinsley	7:00 AM	3:00 PM
J. B. Stadsburg	3:00 P.M.	11:00 P.M.
N. S. Bennett	11:00 P.M.	7:00 AM.

Note: Report any troubles on back side of this report

J. K. Marquis
ENGINEER IN CHARGE

Fig. 1. Pumping Plant Daily Report Blank

Fig. 2.

SPARTANBURG WATER WORKS

FILTER PLANT DAILY REPORT

Date April 6 1927

CHEMICAL ANALYSIS

RAW WATER

TIME	TURB. P. P. M.	ALK. P. P. M.	CO_2 P. P. M.	PH CONC.	COLOR P. P. M.	ODOR HOT	ODOR COLD
1:00 Am.	70	18	8	6.6	X	X	X
8:00 Am	70	18	8	6.6	X	X	X

FILTERED WATER

TIME	TURB. P. P. M.	ALK. P. P. M.	CO_2 P. P. M.	PH CONC.	COLOR	ODOR HOT	ODOR COLD
12:00 Pm	X	14	4	7.0	X	X	X
8:00 Am	X	13	5	6.9	X	X	X
8:00 Pm	X	13	4	7.0	X	X	X

CHLORINE TREATMENT

WEIGHT OF DRUM

12:00 M.	7:00 A. M.	12:00 N.	6:00 P. M.	12:00 M.	TOTAL POUNDS	POUNDS PER MIN.
100¼	99	98½	98¼	98	2¼	1/10

ORTHO-TOLIDINE TEST

12:00 M.	3:00 A. M.	3:00 P. M.	7:00 P. M.
Free	Trace	Trace	Trace

FILTERS

OPERATION

NUMBER IN OPERATION	TIME ON	TIME OFF	RATE OF FILTRATION
6	12:00 M	3:20 Pm	4,500,000
6	10:00 PM	12:00 M	4,500,000

TIME WASHED

1	2	3	4	5	6

Alum emptied into machine 200 Pounds

Alum used per gallon 0.45 Grains

Lime emptied into machines 100 Pounds

Lime used per gallon 0.20 Grains

Wash-water Meter at midnight 13572 Gals.

Wash-water Meter last night 13572 Gals.

Wash-water Used 0 Gals.

Wash-water in per cent of pumpage 0

REMARKS:

OPERATORS

NAME	TIME ON	TIME OFF
B.B. Tinsley	7 Pm	3 Pm
I.B. Steadman	3 Pm	11 Pm
W.G. Bennett	11 Pm	7 Am

J.K. Wasson
ENGINEER IN CHARGE

Fig. 2. Filter Plant Daily Report Blank.

ard letter head, 8½ by 11 in. This particular size was adopted because of its convenience for filing.

Filter Plant Report.—The filter plant report is of the same size as the pumping plant report but of a different color in order to distinguish easily between the two. A reproduction of this report is shown in Fig. 2. This report contains spaces for the physical and chemical analysis of the water. Columns are provided for the turbidity, alkalinity, CO_2, hydrogen-ion concentration, color, odor, both hot and cold, of both the raw and filtered water. Under the head of filters comes their operation, the time they were started, stopped, washed, the rate of filtration, loss of head, etc. The rate controller charts show the operation of the filters but it only takes the operator a moment to record this data on the report where it is more convenient to locate. This report is made in duplicate, one copy being retained in the laboratory, the other copy coming to my office. Some standard form of report such as this, I think, is preferable to the keeping of laboratory note books. The note book may get misplaced or it may not be possible to always get note books of the same size or kind, whereas, a standard sized report can always be duplicated by the printers.

Records of Bacterial Examination.—The results of bacterial examination are tabulated separately from the filter plant report just described, see Fig. 3. Inasmuch as one man alone is solely responsible for the bacterial analysis it was deemed necessary to keep this report separate from the others. This report is also made in duplicate, one copy being retained in the laboratory, the other going to the plant office where the results are transferred to the general office record, thence it is passed along to the superintendent. This report has columns for the source of the water, date, gas production of .I cc. I cc, and 10 cc samples, and the records of plate counts, etc. Regularly daily tests are run on both the raw and filtered water, the results being tabulated on this report.

General Office Record.—The reports just described, together with the automatic records of the venturi meters,

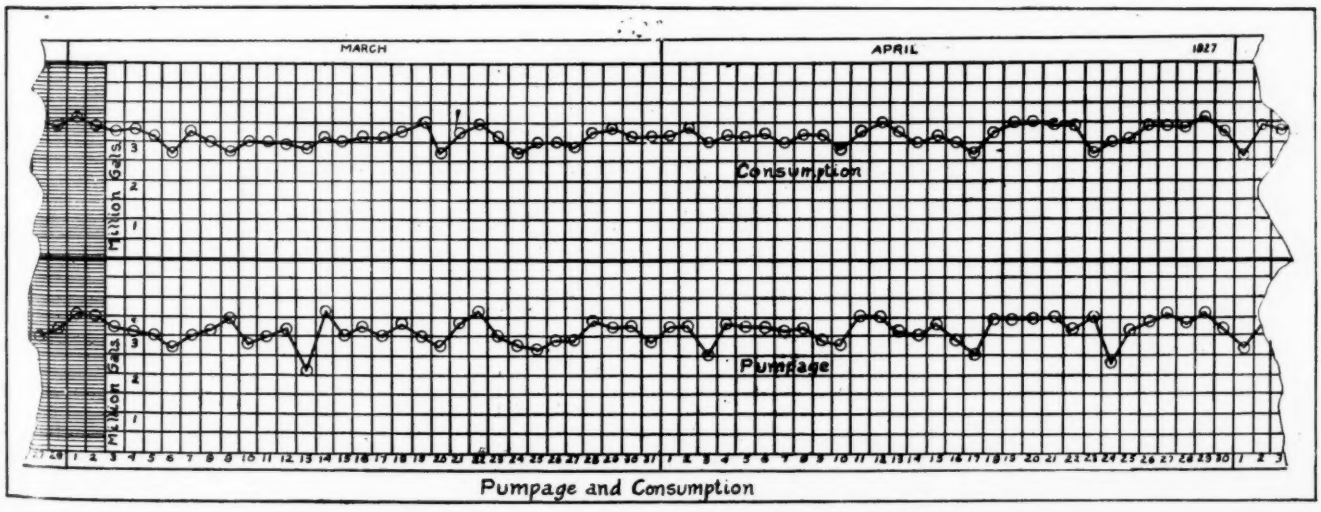


Fig. 4. Curves Giving Comparison of Pumpage and Consumption.

rate controllers, pressure gages, are placed on my desk by the operators. The data collected on these various reports are transferred to the general office record after which they are filed away in a steel cabinet. The general office records are divided into two parts, the filter plant record and the pumping plant record, each being kept on separate sheets. These records are of the loose leaf type and they are kept in a specially made binder. These two records show the operation of the plant in its entirety. This, I believe, is the most convenient way to keep the records as it is but a matter of just a few moments to look up records of past performance. These sheets contain one month operation and at the bottom are to be found the totals and averages.

Graphical Records.—Graphical records of plant performance, if continuous, will be found to give very interesting information and they afford a vivid picture of plant operation. The writer has found that the keeping of such records is time well spent. These graphs are kept on engineers' standard profile books, one book having capacity enough for two or three years' records. Figures 4, 5 and 6 are tracings taken from these books. On these graphs are plotted such data as pumpage, con-

Tabulated Results of the Bacteriological Examination of the Spartanburg
Water Supply South Pacolet River, 1927. 4/9

Fig. 3.

SOURCE	DAY	NUMBER OF COLONIES PER C. C. ON 1% LACTOSEAGAR PLATES	GAS PRODUCTION IN 1% LACTOSE BILE			REMARKS
		Incubated 48 Hrs. at 37½ Degrees C.	1-10 c. c. 24-48	1 c. c. 24-48	10 c. c. 24-48	
Raw	9	350	- -	5-10	20-35	Raw water sample taken at influent of Mixing Chamber.
Filt	9	—	- -	- -	- -	Filt. water sample taken from Clear well

Sig. B. B. Tinsley

Fig. 3. Form for Recording Bacterial Examination of Water.

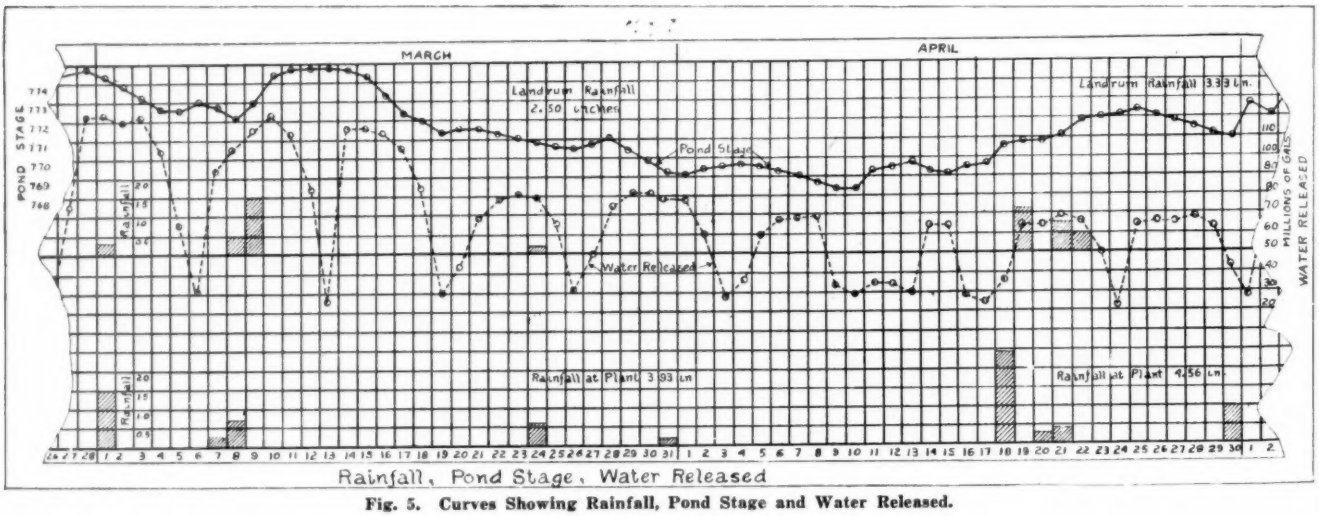


Fig. 5. Curves Showing Rainfall, Pond Stage and Water Released.

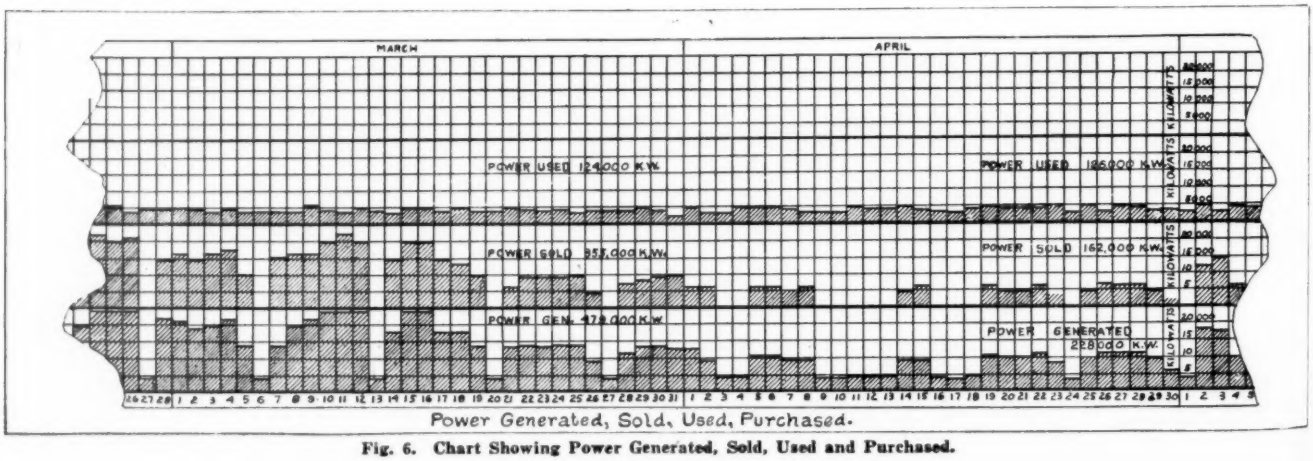
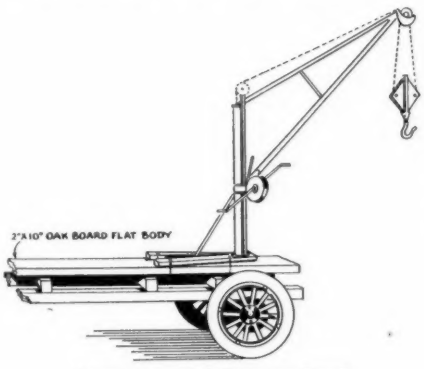


Fig. 6. Chart Showing Power Generated, Sold, Used and Purchased.

sumption, rainfall, pond stage, water released through the wheels, and power generated, used, sold or purchased. These graphs are posted once each month and the amount of time required for their posting is about three hours. They are very valuable in obtaining information on some particular phase of plant operation. Take the rainfall data for instance, if rainfall and turbidity are to be compared, the turbidities are plotted on the graph. Such a comparison will show the rise of turbidity for a given rainfall and the time elapsing between the rainfall and the point of maximum turbidity. Many other things might be mentioned that could be plotted on these graphs in order to form comparisons. The information gained by making such graphs will be found to be very valuable.

Builders Hoist Mounted on Truck Sets Fire Hydrants

Often a great deal of heavy hand work can be avoided by the use of some simple rig. Ideas for these things spring from continual association with the individual parts of the work or from discussion, in many cases, of the work to be done and ways and means of doing it. The hustling and efficient contractor never fails to discuss with his superintendents and foremen various methods of doing the individual parts of a job. As an illustration of this point take a successful contract, a water works job, just completed by W. E. Boyce & Co. at Gulfport, Fla. Universal joint pipe, none of which were over 8 in., were spread along the line of work directly from the cars. All fittings and hydrants were stored in the yard beside the tracks.



Arrangement of Hoist on Truck

The utility crew, which consisted of two young men with necessary tools on a Ford ton truck, spotted all the fittings as required and set all the hydrants. Mounted on the rear end of the flat bed of the truck was a Sasgen builders' hoist. The outfit proved to be a handy, labor saving arrangement for setting fire hydrants, buckling broken pipe out of line, and doing the necessary running around. It was a simple rig and effective. The truck could go anywhere, carry all its necessary tools, load from any position and lift quite a heavy load. The sheave, through which a cable runs from the head pulley to the windlass, can be pulled 50 ft. away and hooked onto a valve, timber, pump or other load and dragged to the truck.

In setting hydrants the truck is backed or driven up along side the hole and the sheave spotted over the connection where the hydrant is to be placed. The setting is easily accomplished because a dog on the windlass holds the load just where it is desired. The rig also came in handy for pulling short sheet piling.

Field Demonstration of Modern Water Works Practice.—An interesting feature of the convention of the California section of the American Water Works Association last October at San Jose, Calif., was a practical field demonstration of modern water works practice, staged in St. James Park just opposite the convention hall. This was an innovation designed to give all water works men an opportunity to visualize standard practice methods and some especially difficult and unusual service connection problems. Exhibits and demonstrations covered the general ground of cutting and welding fittings, making ½ to 12 in. taps on mains under pressure, gas and electrically welded taps, cement caulked joints, insulated services in galvanized screw, brass and cast iron pipe, electrolysis bonding, solder taps and a 500-lb. pressure test on cast iron pipe with caulked cement joints.

Cost of Well Point Trench Drainage

Experiences Recorded on Recent Work at Clearwater, Fla.

By CHARLES E. NANCE
Subcontractor for Peninsula Construction Co.

The wide use of well points in trench work through wet ground makes a statement of the cost of this method of drainage a matter of interest to many contractors. Costs reported on a job in Florida by the writer, where he laid a sewer under subcontract for the Peninsula Construction Company, Dunedin, Fla., during the spring of 1927 are representative of conditions that will be found in other sections. The job involved the laying of 840 lin. ft. of 24 in. pipe in Marshall St., in Clearwater, Fla., in cuts running from 12 to 14 ft. deep in sandy soil. The water table was found at about 6 ft. below the surface.

To do the work, the trench was sheeted, and well points were installed about two ft. outside the sheet piling on each side of the trench at 5 ft. intervals. These points were driven so as to be about one ft. below the flow line of the pipe. In any event a well point must be level with the flow line of a pipe or below it to clear the trench of water.

Four men were hired to handle these well points, at wages of 40 and 50 ct. per hour per 10 hour shift. It was found that these four men could pull and set 120 lin. ft. of points or 50 points, per shift. Jetting down the points in the usual manner by hooking the lines to the discharge of the pump instead of to the suction as they are normally operated. Of course the figures given do not include the cost of the equipment itself or the rental charged to the job to allow for the cost and depreciation of the equipment.

Exact cost records were kept on this job. The work began on Feb. 4 and ended on Feb. 18, a total of 14 days. The records show the following costs:

Night Pump Man, 12 hrs., at 50 ct., or $6.00 per day, for 14 days	$ 84.00
Laborers on Points, 14 days of 5 hrs., at 40 ct., 4 men totaling $8.00 per day	112.00
Day Pump Man, 12 hrs., at 50 ct., or $6.00 per day, for 14 days	84.00
Total Payroll	$280.00
Total Footage	840
Cost Per Lin. Ft.	32.5

It will be noted here that the above table showed that the point gang worked but 5 hrs. a day, and thus laid but 60 lin. ft. of points per day. If they had worked at this for 10 hrs. a day, the unit cost would have been approximately 24 ct., presupposing a progress sufficient to keep them busy for this length of time.

Rates for Irrigation Water.—The following table from the recently issued report of the Water Department of Pasadena, Calif., shows the rates charged by the department for water furnished for irrigation purposes:

⅝ in.	meters	$ .45
¾ in.	meters	.50
1 in.	meters	.60
1½ in.	meters	.85
2 in.	meters	1.10
3 in.	meters	1.85
4 in.	meters	2.35

Rate for irrigation service is $0.06 per 100 cu. ft. plus the above monthly service charge.

Air Plane Control of Mosquitoes.—In his annual report the Surgeon General of the U. S. Public Health Service states that malaria studies of the service have demonstrated the possibility of airplane control of mosquitoes in otherwise inaccessible areas by spreading larvicidal dust.

Kansas Water Works School.—The Water Works Conference and meeting of the Kansas Water Works Association will be held Feb. 14, 15 and 16 at Lawrence, Kan. Ernest Boyce, Lawrence, Kan., is Secretary-Treasurer of the Association.

Traffic Control and Good Lighting

Their Importance in Reducing Congestion and Accidents Discussed in Paper Presented Nov. 17 at Annual Convention of American Society for Municipal Improvements

By A. F. DICKERSON

Chief Engineer, Illuminating Engineering Laboratory, General Electric Co.

In a recent count on one of the main traffic arteries of a city of 100,000 it was found that approximately 20,000 persons in automobiles passed a certain point during 24 hours.

If traffic control will save five minutes in traversing this street, the daily saving would be over 1,600 man hours. When the magnitude of this possible saving is realized even though reduction in accidents is not considered, there can be no excuse for not installing a traffic control system.

Since most of our congestion and greatest losses in time today are on our main traffic arteries, the scope of this paper is largely confined to a discussion of how these streets may be relieved and why immediate action is necessary and economical.

Except in certain short and very congested areas, the platoon system of control, whereby blocks of traffic move in jumps, has not proved successful in increasing speed, although it has been responsible for a considerable reduction in accidents. Modifications of the platoon system have and are still being tried with varying degrees of success, depending on local conditions.

Progressive and Co-ordinated Traffic Cotnrol.—The one outstanding development that bids fair to supersede all others, especially on long radial arteries, is the progressive traffic control, which can be co-ordinated with the controls of intersecting streets.

Briefly, such a system insures the constant, or almost constant, movement of traffic in both directions on both the controlled and the intersecting streets at a fairly high speed. The success of such a system depends largely on the motorist. He must at all times proceed at the speed for which the system has been designed. Average speed becomes constant speed. Short bursts of speed with frequent stops invite accidents and never cover as great a distance as a much slower constant speed.

With the progressive system of control, traffic proceeds in a continuous wave. Signals flash green progressively, always just in time to prevent a decrease in speed by the approaching motorist. If a motorist increases his speed above that prescribed for the system, he will surely be stopped at the next signal by the red light. In many instances, where long blocks of equal length prevail, cross traffic also moves without interruption. Congested cross streets or irregularity in block lengths may occasionally make short stops necessary.

On account of the great lengths of our arterial streets, the problem of wiring connections, which seemed necessary to accomplish the progressive flashing of signals, and its great expense for a time doomed this so-called "Ideal System" to rather limited usage. Necessity, however, again proved to be the mother of invention, so today progressive signalling may be had without any wiring interconnection between signals.

The Synchronous Motor Timer.—The synchronous motor timer, which is the very heart of the system, provides the necessary flexibility and eliminates the most expensive item of construction—interconnecting cables between intersections. This synchronous motor timer with switches and accessories—all in a suitable housing—is located as a separate control at each intersection, the motor being kept connected across the line at all times. As there are no interconnecting cables, local feed is required for the signals. By virtue of its absolutely constant speed at any specific frequency, the motor operates in synchronism with all other controllers or timers in the system that are on the same frequency.

Please mark the simplicity and effectiveness of these synchronous motor timers as applied to the progressive and coordinated traffic control system. The initial setting is determined according to the desired rate of vehicular progress; the consecutive signals will thenceforth appear in an undeviating time sequence; traffic enters the controlled area in groups and observes the predetermined speed; at each intersection, the green, or "go" light appears and, so to speak, hands the driver on to the next signal and the next—and so on to the end of the area.

Meanwhile, the cross traffic moves through the gaps on the main avenue traffic. The percentage of time allowed for each intersection is carefully and independently adjusted to its needs. If these conditions should change for any cross street, or in any block of the main street, the proper increase or decrease in time for either street can be made at any time without interfering in any way with the original setting of the control for progressive movement on the through avenue.

No Cable Interconnection Needed.—To these advantages should be added two important matters of economy. No cable interconnection is needed and thus the heavy expense of cable and its installation is avoided. The system is capable of indefinite extension without involving additional current-carrying or relay apparatus, since the installation at each intersection is a separate unit fed directly from the commercial secondary current. In a word, progressive or co-ordinated traffic control systems combine economy with the ability to handle peak-load traffic as easily as light traffic and to move maximum traffic in both directions with the least delay and at any predetermined speed or speeds.

With the ever-increasing night traffic on our streets and highways, the use of light, as a protective measure, is being overshadowed by its absolute necessity to insure high-speed traffic with safety. Traffic counts on most of our radial arteries will show maximum peaks between five and six-thirty o'clock in the evening. In the winter these are hours of darkness or twilight. Lower peaks usually occur in the evening between seven and eight o'clock. On many streets the average hourly night traffic to midnight exceeds that of the daylight hours. More than half of the accidents on these streets occur after sundown.

Need for Sufficient Lighting.—Traffic control or regulation is designed to relieve congestion. During times of peak traffic, congestion is relieved principally by increasing average speed. By systems of progressive control, cars on main thoroughfares may maintain speeds higher than 25 miles an hour with safety in daylight. At night, unless sufficient lighting of the proper kind is supplied, drivers automatically decrease their speed below that for which the control system has been set, resulting in frequent stops with accompanying congestion. If an attempt is made to maintain the prescribed high speed on the poorly lighted street, frequent accidents will follow.

A traffic control system is installed by a city and if accidents result from the increased speed permitted, the city's government is morally responsible and should take steps to correct the situation. One of the first steps should be to light the street adequately. This lighting is a function of the city and not of the abutting property owners. Increased traffic, excepting on a business street, is generally a detriment to abutting property and the cost of the lighting which will tend to increase traffic should be borne entirely by the city. If the property owners demand standards and fixtures of a highly ornamental nature, then perhaps they

should share in the installation expense.

This brings up the question, should municipal street lighting budgets be increased and what is a fair yearly expenditure per capita for street lighting?

Comparative Expenditures of City Departments. — The following chart shows the comparative expenditures during 1919 and 1924 for the various departments of all cities in the United States of over 30,000 population. This information was compiled from reports of the Census Bureau, 1924 being the latest report.

Table I.

	1919		1924	
	Dollars	Per cent	Dollars	Per cent
Street Lighting	.72	3.4	.87	2.4
Highways (incl. street ltg.)	2.04	9.6	3.13	8.05
Charities Hospitals Corrections	1.59	7.3	2.09	5.9
Schools	6.88	31.7	13.54	37.9
Libraries	.28	1.3	.44	1.2
Recreation	.74	3.4	1.16	3.3
Misc. & General	1.01	4.7	1.68	4.7
General Government	2.22	10.2	3.02	8.5
Health Conservation	.58	2.7	.96	2.7
Sanitation	1.76	8.1	2.71	7.6
Police	2.33	10.8	3.63	10.3
Fire	1.83	8.46	2.93	8.2
Other Protection	.37	1.74	.59	1.65

An examination of these charts discloses the fact that while the general per capita cost of government has risen over 68 per cent in the 5-year period, expenditures for street lighting have only gone up less than 21 per cent. In 1919 our streets were inadequately lighted and we were spending 3.4 ct. of every tax dollar for street lighting. After five years of tremendous expansion in motor transportation we find this figure reduced to 2.4 ct.

Some may point to these figures with pride. Such a remarkable saving! But is this saving justified when one considers the enormous loss in time due to congestion and slow speed, and the great increase in night accidents with the resulting injuries, deaths, and property damages.

Per Capita Expenditures for Street Lighting.—The average annual per capita expenditure for street lighting in the cities of this country with over 30,000 population was 87 ct. in 1924 and is probably about 95 ct. now. It would be far better economy to spend two dollars. The over-all service purchased by the $7.15 spent for safety and protection in 1924, could have been greatly improved by a re-allotment which would have increased the street lighting budget.

There are a few large cities now spending over $2 per capita for street lighting and many more have approved plans which will call for such an expenditure. The average for the best lighted fifty cities in this country is now about $1.50. The yearly cost of street lighting will vary from about 2 ct. per linear foot of street for the poorly lighted village to nearly $15 for an intensive "White Way" system such as is on State Street, Chicago. If it is a good investment for a property owner or merchant to pay $15 for lighting 1 ft. of street, surely it is well worth while for some cities to consider increasing their present expenditures.

It is a well-known fact that light increases the speed of vision and is, therefore, an aid in speeding up traffic. Statistics prove that night street accidents are also materially reduced by light. In the city of Cleveland there are several major thoroughfares leading east with double track street car lines. In 1923, statistics showed one night fatality on Euclid Avenue and one on Woodland, both of which were well lighted, while there were eight on Superior and seven on St. Clair where there was poor lighting. This was true in spite of the fact that in the daytime more people were killed on the first two streets. More than two years ago Superior Avenue was brilliantly lighted with a system of 25,000-lumen lamps and since then there has not been a night fatality.

Recent statistics from a large number of cities show that approximately 20 per cent of our night traffic fatalities are directly due to insufficient street illumination. In Cleveland, estimates indicate that the proper lighting of all the streets would save 33 lives each year, or 39 per cent of the total killed in automobile night accidents.

The quantity of light and the type of lighting to be used on a traffic artery will depend largely on local conditions, amount of traffic, tree interference, street surface, and many other factors. In this paper only general recommendations for average conditions will be given.

Visibility of Prime Importance.—In appraising a street lighting system, visibility is of prime importance. The amount of light reflected by an object in the direction of the eye is not a measure of its visibility. In other words, photometers do not measure visibility. Our vision does depend on the brightness of the retinal image and this brightness is in proportion to the amount of light that enters the pupil of the eye. The normal pupillary opening can contract to one sixty-fourth of its greatest dilation; so it is quite apparent that the visibility of an object will be greatly lessened by anything that tends to close this opening. This explains the importance of reducing glare, in so far as possible on city streets.

Today the greatest glare factor on our traffic arteries is the automobile headlight, although there are available non-glaring headlights. Steps are being taken to curb this evil, even to the extent of compulsory dimming; so lighting systems should be designed to reduce glare to the practical minimum even though it may not be objectionable under present conditions. All modern automobiles are equipped with visors which cut off the street luminaires long before the maximum ray is intercepted, so there is slight chance of glare to the driver when lighting units with 80 degree maximum rays are mounted 20 ft. or more above the pavement. When it is necessary to adopt 15 ft. standards, a 77½ deg. distribution should be used. It is quite evident that low standards require close spacing to preserve the proper distribution of light.

The term "lumens per linear foot" which is more often used, is a measure of light output and while it does not take into account the proportion of light which reaches the street surface, it is a convenient measure of the comparative value of systems when used in connection with properly designed street lighting. This value is easily obtained by dividng the total bare-lamp lumens of each standard by the number of linear feet of street per standard, or the total lumens of all the lamps by the linear feet of street lighted.

Lighting Recommendations for Traffic Streets.—Traffic streets should be lighted to a sufficient degree to permit the operation of motor vehicles without bright headlights. The amount of light necessary will vary from a minimum of about 40 lumens per linear foot to a maximum of several hundred for the wide streets with heavy traffic. Table II of recommendations covers good lighting on the average traffic artery in the classification indicated.

Table II

Lighting Recommendations	Classification by Population		
	Over 100,000	30,000 to 100,000	Below 30,000
Lumens of lamp	60,000-10,000-15,000	6,000-10,000	6,000
Arrangement of standards	Staggered	Staggered	Staggered
Feet of street per standard	75-150	100-150	100-150
Lumens per linear foot	60-200	40-100	40-60
Height of upright unit	15-18 ft.	15-18 ft.	15-18 ft.
Height of Pendent unit	20-25 ft.	20-25 ft.	20-25 ft.

Considerable leeway is given in the above table but deviations from it will often be advisable. For instance, very wide thoroughfares in large cities will probably demand an opposite arrangement of standards and in some cases the installation of two-light standards may be advisable. From a strictly utilitarian viewpoint the system with pendent units is the more efficient. With the higher mounting heights, spacing can be materialy increased and larger lamps used.

Street Lighting Fixtures.—In all pendent fixtures and in most upright units refractors or reflectors can be used to advantage. Where light on buildings or porches is objectionable, it should be refracted or reflected into

the street. Some light on buildings and in the trees is necessary in the reduction of glare by lessening the contrast between the luminaire and its background. Such light also adds to the cheerfulness of the street. Sidewalk lighting with minimum shadows is necessary and a certain amount of light between buildings is essential for protective purposes.

There is a variety of luminaries and standards that have been designed primarily for the lighting of thoroughfares. In general they should be inconspicuous but pleasing in contour to the observer. Illuminating efficiency is of paramount importance. Fortunately, beauty in design does not necessarily detract from this feature nor does it make the equipment more expensive.

Once a system of lighting is installed, constant attention to its proper maintenance will prove good economy. It is not uncommon to see street lighting fixtures operating at half their initial efficiency because of the accumulation of dirt, the improper adjustment of refractors and reflectors, or the burning of lamps long beyond their rated or economical life. Proper maintenance may not cost more than five per cent of the total expense of the system but improper maintenance might, and often does increase the cost of useful delivered light by 50 per cent.

While it is intended that this paper shall primarily deal with the lighting of traffic arteries within the city limits, it would be incomplete without some mention of highway lighting. Because of the increased speed and also the proximity of opposing traffic lanes with the resultant danger from headlight glare, serious accidents to the occupants of automobiles are more common on the highway than on the city street. That highway traffic can be speeded up safely and with more comfort to the driver under properly designed systems of illumination has been conclusively proved in many instances.

In summary, it is hoped that this paper has pointed out; first, the usefulness of systems of traffic control; second, the resulting need of good lighting in order that they may properly function; third, the necessity of such lighting if night accidents are to be reduced; and fourth, the relatively small expense of good lighting and the justification of an increase in present expenditures.

In conclusion, an effort has been made to indicate the important elements in the design of a system of illumination for a traffic artery. The recommendations included must, of necessity, be of a general character. However, they can be readily adapted or altered to conform to local conditions.

New Mexico Traffic Census and Tourist Questionnaire

In September the Highway Department of New Mexico undertook a census of traffic on all main traveled highways of the state. Additional information in particular regard to tourist travel was obtained from post card questionnaires placed in the hands of non-resident motorists visiting New Mexico during that month. The distribution of these questionnaires was effected through co-operation with garages, chambers of commerce and tourist camps throughout the state and appreciation is extended them for their assistance.

The department experienced some misfortune in selecting the period for the count and distribution of questionnaires (Sept. 11-18) on account of severe rains and flood conditions which held sway in certain sections. However, except for abnormalities noted in counts taken in these localities, the results of both the census and questionnaire campaign were satisfactory and highly informative.

The traffic census of this year is a more detailed record than has been secured heretofore. Counts were taken at 132 stations as against 70 last year and 64 in 1925. Traffic on all interstate highways was carefully recorded at or near the state line. Counting stations were located to obtain actual conditions of travel as nearly as possible rather than expediently selected because a project engineer or maintenance camp was located close by.

Almost all highways show a normal increase in traffic over last year when identical counting stations are compared. These increases range from 10 per cent to as high as 90 per cent and 100 per cent in a few instances.

Eight stations in the state indicate a volume of traffic passing these points exceeding 1,000 vehicles per day.

The roads bearing the heaviest traffic are naturally near the largest centers of population, local travel largely influencing the figures. As would be expected, the greatest volume is in the vicinity of Albuquerque on U. S. Highway 85, with a daily average of 2,731. Second in volume of traffic comes the paved road between El Paso and Las Cruces (1,830 per day). The Carlsbad-Pecos, Texas route near Carlsbad stands third in order, with 1,572 daily average. A short stretch east of Roswell toward Tatum is fourth; Gallup-Gamerco fifth, and U. S. highway 85 between Albuquerque and Santa Fe, sixth.

The number of foreign or non-resident cars counted is 35 per cent of the total—exactly the same percentage as obtained last year—indicating that the increases in local and tourist traffic have been identical. Assuming that tourist travel is greater in September than for an average month, the volume of traffic represented by non-resident travel can be conservatively placed at 30 per cent of the total for the year. Receipts from the 5 ct. gasoline tax may safely be estimated at $1,500,000 annually; therefore, non-resident tourists pay not less than $450,000 each year directly toward road maintenance and construction. The road maintenance budget for the 1928 fiscal year is $880,000, hence non-resident motorists assume not less than half the maintenance costs.

The gasoline sales and consumption represented by this $450,000 would be 9 million gallons. Assuming 15 miles of travel per gallon of gas, the resulting annual mileage of non-resident tourist travel is 135,000,000. From the tourist post card questionnaire returned to the department, it has been determined that the average tourist car travels 572 miles in the state. Using the above figures as a basis, 236,600 non-resident cars visit New Mexico each year. These questionnaires also show the average number per car to be 3 and the average expenditure per person to be $23. The annual influx of visiting motorists is therefore conservatively estimated to be 709,800. The amount of money spent by them in the state yearly to be $16,325,000, a very respectable sum, and one which is increasing each year. These figures do not include the large and rapidly increasing number of tourist visitors coming to the state on the railroads as a result of the Harvey Company Indian Detours and intensive advertising on the part of all railroads entering New Mexico, largely made possible by New Mexico's excellent roads.

It has been deduced that 236,600 motor cars carrying 709,800 tourists visit New Mexico annually. The average number in each party is three. Each car and party remains for a 5½ day average sojourn in the state, the extreme limits being represented by a minimum of several hours and a maximum of four months. Each such party spends $68.84 while in the state, the smallest party expenditure recorded being $2.00 and the greatest $1,100.00. Each visiting automobile travels an average distance of 572 miles in New Mexico. The distances for individual cars range from 25 miles to 10,000 miles. The occupants of 62 of every 100 cars stop at private or municipal camps, 30 per cent stop at hotels, almost 5 per cent do both and less than 2 per cent are entertained in private homes. The small number remaining take advantage of various combinations of all ways.

Interesting Water Tower Designs

English Scholarship Competition Brings Forth Drawings That May Suggest the Future Trend of Ornamental Concrete Water Tower Design, and These Will Interest the American Water Works Official

A series of designs of reinforced concrete water towers submitted in the course of a recent British scholarship competition will interest the American designer, since they show architectural possibilities that may be encountered in designing a structure of this type.

According to the "Structural Engineer" the official journal of the organization sponsoring the scholarship, to whom we are indebted for the information given here, the occasion of the competition was the first award of the Brenforce Travelling Scholarship, recently instituted. This scholarship is awarded and governed by the Council of the Institution of Structural Engineers, London, and is open to members, associates, associate-members, graduates, and students of the Institution of Structural Engineers between the ages of 21 and 40 years, is awarded every third year, beginning in 1927, and besides a gold medal, silver medal, and bronze medal, carries a prize of 300 pounds sterling ($1,500) to the winner, to be spent in travelling for 42 days on the continent of Europe in the study of the development of the aesthetic design of concrete and reinforced concrete buildings. A sum of $250 is withheld from the total scholarship until the completion of this tour and the subsequent completion of a satisfactory thesis covering the observations of the scholar during his study tour.

The subject of the first competition was announced as the design of a water tower in reinforced concrete. This tower was to be planned for erection in an exposed commanding position on an eminence in moorland country, and provided with a balcony open to the public. The tank was to hold 250,000 gal. of water and was to be supported at a height of 100 ft. above the ground. Easy access was to be provided to the roof of the water tank for purposes of inspection, while provisions were also to be made for inlet and overflow.

The entries brought out the fact that there may be two conceptions of such a structure, the first a recognition of the tank as an object worthy of embellishment, and as opposed to this idea, the conception of a tower in which the tank is concealed. Many entries betrayed a compromise between these two ideals.

Three winning designs are shown here. Figs 1 and 2 show the perspective and the structural design of the prizewinning design, submitted by Mr. J. Blackett. This design won him the gold medal and the travelling scholarship, since it was considered best by the judges of the contest.

He has chosen for the form of his tank a simple shape, capable of economic construction, while the balcony which is placed beneath it has just the right emphasis in the general conception of the design. The screen wall is treated in a particularly skilful manner inasmuch as it appears in the form of panelling set between four great buttresses which give architectural expression to the main structural members supporting the tank. These latter, while admirably serving their utilitarian purpose, give a decorative quality, and their position is reflected in the projecting ornamental features appearing on the outside of the tank. The screen wall itself is punctured by windows, few in number and small in dimension, which rightly suggest that

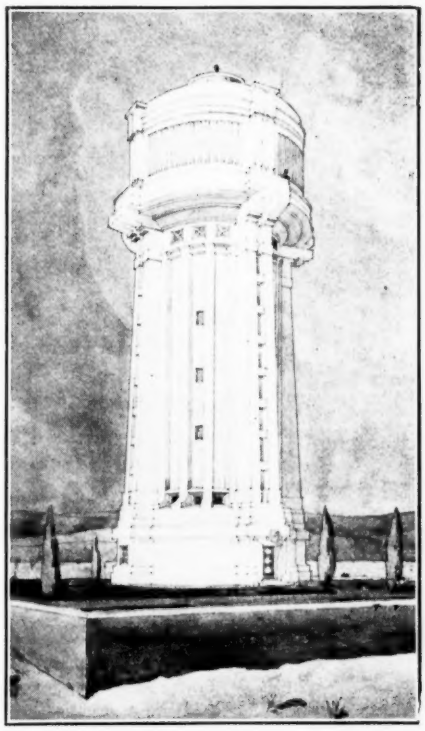


Fig. 1. Perspective of Water Tower Designed by J. Blackett, the Winner of the Scholarship

the space behind them does not consist in habitable rooms but comprises a single tall chamber extending from base to the under side of the tank. The staircase admitting the public to the balcony receives sufficient light and ventilation through these windows. A particularly clever feature in the design is that the depth of the projections on the outward face of the tank makes possible the provision of a very small staircase giving access to the roof of the water-tank for purposes of inspection, and this is achieved without interfering with the beauty of the design and also without necessitating the expensive device of bringing of the public staircase to the higher level. The base of the structure is very well designed, the effect of solidity being obtained by dispensing with windows at this portion of the façade. Adequate light, however, is admitted through small windows obliquely set in the band of wallage separating the base from

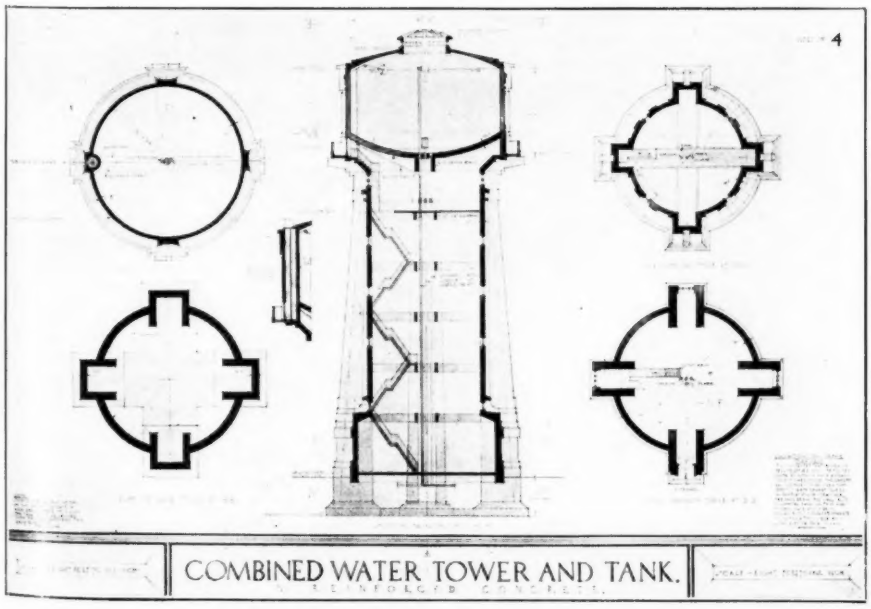


Fig. 2—Plans and Section for Tower Shown in Fig. 1

Fig. 3. This Monumental Tower Was Designed by the Winner of the Second Prize

Fig. 4. Here Is the Version Entered by the Winner of the Third Prize

its superstructure. The design has been carefully thought out and is illustrated by a fine set of drawings.

Mr. S. H. Suthers, awarded the Silver Medal, decided to give to the tank the minimum of architectural emphasis. He has, however, produced a design (Fig. 3) having a fine monumental quality. He has conceived the structure as primarily a tower, and although the vertical dimension of the tank has been indicated on the façades, this feature is not allowed to assume great prominence. Owing to the fact that the conditions of the competition prescribed a balcony for the use of the public he has chosen to provide additional accommodation for its convenience in the form of lavatories and a small refreshment room. The approach to the tower is by means of a wide flight of steps giving access to the public gallery around the base of the tank. The summit of the tower is gained by means of a further staircase passing through the center of the tank. The tank itself is supported through "T" and main beams of 16 columns, which are cross-braced at intervals to form wind bracing. This scheme is also well presented, and while the subject of the design is not so well understood as by the winner of the scholarship, Mr. Suthers has produced a scheme of great originality.

Mr. Edwin Williams, who was awarded the bronze medal, also submitted a very fine set of drawings. His design (Fig. 4) has the virtue that it gives separate expression to both tank and gallery in such a manner that each of these features has its proper relative importance in the design. The supporting screen wall is appropriately treated with its fenestration suggesting a single chamber behind it. The building has a very elegant profile, but the base, although well articulated, appears to enclose a large space which is put to no apparent use.

Growth of Sewerage in Philadelphia

In a discussion in the January, 1928, proceedings of the American Society of Civil Engineers, Mr. George S. Webster, Consulting Engineer, Philadelphia, outlines as follows the growth of the sewer system of Philadelphia:

Philadelphia was one of the first of the large cities in the United States to be laid out on a systematic plan. This was done in 1682 by Thomas Holme, Surveyor to William Penn, the first proprietor of the Commonwealth of Pennsylvania. In the development of these early plans, provision was made for drainage systems.

The first of these drainage channels was built about 100 years ago. They were built of bricks laid with dry inverts, that is, without mortar joints; were generally 7 or 8 ft. deep and were intended to carry off both surface and ground-water. No buildings were connected with them at that time. Later, many of these drainage channels became part of the combined system of sewers of the city. The first effort to determine the size of sewers for run-off was made by the Board of Aldermen and not by the City Engineer. The Aldermen decreed that all branch sewers should be 3 ft. in diameter.

In 1875, the writer was in charge of a Field Corps of Engineers at the Centennial Exposition Grounds in Philadelphia and, under direction of those in authority, gave lines and grades, and supervised the construction of sanitary sewers discharging directly into the Schuylkill River above the dam and into the pool from which a part of the city's water supply was taken and furnished without treatment to the citizens. At the time of the Centennial Exposition in 1876, the late Rudolph Hering, M. Am. Soc. C. E., obtained from the Swiss Exhibit, a diagram showing the Ganguillet and Kutter curves for the flow of water in channels and the writer made a tracing of it for the use of the City Engineering Department and for the Engineering Profession in general. The first empirical formula of which the writer has any knowledge, that was used for determining run-off when designing sewers in Philadelphia, was "one cubic foot per acre per second," which is equivalent to 1 in. of rainfall per hour, all reaching the sewer. This is not a bad rule for an engineer to use as a rough check on his assistants in calculating run-off for large sewers.

In 1880, the American Public Health Association sent Mr. Hering to Europe to investigate sewerage practice, and his report thereon marks one of the turning points in sewer design in this country as it placed such design on a scientific basis rather than by rule-of-thumb. He brought back with him the Burkli-Ziegler formula. This was thought to be the last word in determining the run-off for storm-water sewers. It was soon found, however, that in a city like Philadelphia, with street grades varying from 1 ft. in 1,000 ft. in the flat sections to 10 per cent, or more, in high suburbs, this formula did not give acceptable results in all cases.

The McMath or St. Louis formula, a modification of the Burkli-Ziegler, was tried for a time. It gave better results, but did not prove satisfactory. The city then established six pluviometer stations for recording intensity, duration, and the amount of rainfall in the city limits and also installed automatic recording flow gauges in a number of sewers; and from the information thus collected, a new formula known as the "Philadelphia formula" was evolved. It was in reality an extension or modification of the Burkli-Ziegler and McMath formulas. This was an advance over previous methods of determining run-off, but did not give correct results under all conditions.

All these investigations led to the adoption of what is called "the rational method of designing sewers" which is based on data collected in Philadelphia and on facts evolved by the late Emil Kuichling, M. Am. Soc. C. E., in his work at Rochester, N. Y.

Finding that the streams into which sewers discharged were becoming very heavily polluted and that the maintenance of public health demanded that some corrective steps should be taken, the City of Philadelphia has adopted a comprehensive plan and has entered on the treatment of its sewage on a large scale. There is in operation a treatment plant on the Delaware River near the Torresdale intake to the City's water supply. At this plant, Imhoff tanks, sprinkling filters, chlorination, and sedimentation are successfully used. In the northeast section of the city, a series of Imhoff tanks have been installed and are in operation, while in the southwestern section, preparations are under way for the erection of a large plant for sewage treatment.

The Pavement Base Situation

Causes of Failures of Concrete Bases discussed. Preparation of Subgrade. Faulty Concrete Due to Poor Material, Hasty Mixing, Poor Workmanship, Excess of Water, Ignorance or Collusion—Seldom the Last. Increased Richness, Thickness and Reinforcement, from Paper Read Before Engineers' Club Philadelphia

By J. H. NEESON
Chief Engineer, Philadelphia Bureau of Highways

Complaints in regard to street conditions in Philadelphia date back to 1705. In 1720, an ordinance was recommended "to restrain the weight of loaded carriages passing over the pavement." A lottery in 1768 provided five thousand pounds for paving streets and making other improvements. An ordinance introduced in 1854 provided for paving with dressed stone, cobble being the prevailing type before this date Thirty-seven years later the use of concrete base was recommended; the history of permanent pavements begins with 1892-93. However, the city found itself in 1919 with pavements inadequate both in quality and quantity.

It is of interest to determine to what agency or agencies can be attributed the failure of pavement bases in streets since 1912, when the Bureau of Highways was placed on an engineering basis and its specifications standardized. For the purposes of discussion, we may discriminate between streets occupied by railway tracks, and those not so occupied. Since the underlying causes of failure may be and are different, we have confined the discussion to streets on which there are no street railway tracks.

Failures of concrete base can be attributed to any one or to a combination of the following causes:

(a) Inadequate preparation of subgrade;
(b) Imperfect and improper replacement of ditches and service cuts;
(c) Inferior concrete;
(d) Inability or failure of the top surface to perform its proper function.

Good Subgrade Needed. — In our judgment, too much stress cannot be laid on the necessity of properly preparing the subgrade for the concrete foundation if it is to be expected to accept the uniform distribution of the loads applied to it directly or transmitted through the base foundation. Particular care should be given to this feature of the construction, not only prior to the placing of concrete but during that operation. The existence of any soft, spongy, or loosely bound areas will be as fatal to the life of the concrete base as fill in trenches opened for underground services in neglect to replace in the most efficient manner the advance of the paving or in checking up on older cuts. Lack of the fullest recognition of these important factors has contributed to the failure of street paving in this city and elsewhere.

In an effort to remedy these causes of defects we have recently included in our specifications the clauses that all backfill in open or recently refilled ditches, whether high or low, must be replaced by mechanical tamping. This is intended to cover also those areas of subgrade found to be insufficient to withstand the strain of applied rolling loads.

In practically all contracts for paving or repaving the engineer must contend at some time or other with a condition known as wet subgrade, a difficult feature to control. Much reliance has to be placed upon the judgment of the engineer and the inspectors in charge of the work; hence the human element enters into the determination of fitness or unfitness of the subgrade. The tendency, which is natural, is to proceed with the placing of concrete in order not to delay the progress of the work or, perhaps, to anticipate another change in climatic conditions. It should be an elementary rule in good construction work to make an interruption at this point if it is to be considered of prime importance that the subgrade shall be thoroughly dried out. No criticism can be directed either at the contractor or the engineering forces for this character of delay, even though by taking chances the work could be expedited. The added insurance of competent paving work should be a sufficient offsetting influence against a desire to secure quantity at the sacrifice of quality performance.

The Concrete Base.—It would seem there should be no disagreement regarding the most vital element entering into street paving construction—the preparation and placing of the concrete foundation. Engineers, laboratory workers, and chemical analysts have concentrated their efforts upon the values of mixes and aggregates that enter into the composition of concrete. But we still find evidence of paving failures traceable to base deterioration. If, as has been established by years of experimentation, pre-cast concrete specimens of given depth and diameter do withstand minimum breaking loads per square inch of bearing surface, should such failure be attributed to the known and accepted traffic loads of today? It is, at least, questionable. The debatable accuracy of physical tests of poured concrete as now generally made results in none too dependable classification and is frequently misleading in showing abnormally wide ranges of values in one operation, thus leaving the matter open to a number of conjectures. There is need for more accurate and satisfactory methods in physical tests of set-up concrete in place, tests that will more reasonably determine at once the worth of slab without resort to chemical analysis except as routine check-up. Attention being directed to the modulus of rupture theory in slab or base concrete through work being done by the State Department and by other testing engineers, may result in the abandonment of present practice. But if the physical laboratory test does show beyond question of doubt that the concrete specimen breaks at or below the minimum accepted requirements and chemical analysis indicates a lack of proper proportioning or the absence of cement and aggregates, we are face to face then with a serious defect and perhaps defection upon the part of those in responsible charge of the work.

How do such situations arise? Briefly, they may be summarized as due to inherent weakness of cement or of sand or gravel or stone; too hasty mixing; to poor workmanship in placing; to the excessive use of water; to ignorance or inexperience on the part of the inspector; and finally to deliberate collusion on the part of the inspector and the contractor or his representatives.

A Street Survey.—As a contribution to this discussion the Bureau of Highways within the last fifteen days has made examinations of pavements on eleven streets placed between the years 1913 and 1926, where we had reason to believe base failures might exist. A total of twenty-seven openings were made and it developed that in eight cases the failures were surface failures only and the base concrete was intact; failure in four other instances was found to be due to improper tamping of ditches in advance of placing concrete; three others were evidently caused by poor sub-grade condition; in two instances the concrete base, laid in 1913, had been shattered and from our knowledge of traffic conditions over

the street in question we judge this was due to impact transmitted through surface wear-outs, which the base was unable to withstand. We may state that, broadly speaking, ten of the twenty-seven openings made revealed evidence of poor concrete. Five of these locations were in one street of considerable length and while there were extenuating circumstances in the way of weather and grade conditions, we must reach the conclusion that in the particular locations opened the concrete was of an inferior quality, since on all sides of the opening the concrete was of good quality. Those spots that failed evidently were "lean" and caused by lack of cement or overloading of coarse aggregates, improper water content or too hasty mixing.

The conclusion is upon observation only, as no chemical or physical tests were made; no doubt one, or a number, or perhaps all of the factors enumerated entered into the disintegration of the base. The incident is brought forward here to illustrate the importance of the relationship between the municipality, the contractor and the inspector, and the necessity for intelligent co-operation. It has been the writer's experience that the great majority of responsible contractors do give a dollar's worth of work for the dollar received; and furthermore, only on rare occasions have we found an inspector who is willing to stand by and tacitly agree to a flagrant violation of the specifications. The first requisite of a good inspector is fidelity and loyalty to the responsibility imposed on him.

Too Much Water.—Rather than place too much emphasis on the lack of cement or disproportioning in cases not proven, our observation has been that in the effort of the contractor's organization to make yardage, there are occasions when good workmanship is sacrificed. Mechanical faults creep in. Water is, on occasion, too freely used with a consequent sloppy mix; the period of mixing is not given the attention it deserves—a fact that is quickly demonstrated in the looseness and raveling of the concrete in drying out. A check-up on 60 per cent of the concrete in operation in the month of July, 1926, by an engineer observer of the Bureau showed that on one-half of these contracts insufficient attention was being paid to water content and the average time of mixing was about 45 seconds instead of 60 seconds as called for in the Philadelphia specifications. These conditions were corrected immediately. Assuming that all the necessary quantities of ingredients have been used and in the proper proportion, the strength value of concrete depends almost entirely upon the mechanics of mixing and placing. The time element can be controlled readily and the specifications of the Bureau of Highways for 1927 do not permit the use of a mixer not equipped with a timing device. The variation in time of mixing in ten other cities is illustrative of the differences of opinion of specification makers: New York, Washington, Detroit, Cleveland and Baltimore require the same period as Philadelphia—60 seconds; Chicago, 50 seconds; Boston and Newark, not specified; while Pittsburgh and Buffalo represent the extremes—90 and 38 seconds, respectively.

Closing to Traffic.—As in the case of timing, there is no common standard adopted by all of the eleven cities mentioned regarding the period of protection of new base from traffic. New York, Newark, Buffalo, Boston and Baltimore do not specify the number of days; Washington requires four; Chicago, Cleveland, Pittsburgh and Philadelphia call for seven; while Detroit seems to be taking extraordinary good care of newly laid foundation by putting up the bars against traffic for fourteen days. This feature seems to be either over or under-stressed; fitness to proceed has been regulated mainly by experience and judgment, without resort to any scientific principle. To the influence of climatic changes and speed may be charged reasonable doubt of the maturity of some of our base foundation, less important perhaps than other factors, nevertheless cumulative in the final analysis. Again the fixing of a water-cement ratio should be helpful in removing "greenness" or "ripeness" from the speculative field. The water-cement ratio, now featured in the discussion of concrete as an index to the ultimate value of concrete for plain foundation, ordinary building construction, or more intricate bridge work, may have an important function to perform in paving base of the future.

Wearing Surfaces.—The increase in the volume, weight and speed of vehicular traffic, particularly motor trucks and buses, is bringing out more pointedly the close relationship existing between the wearing surface and base foundation. Modern traffic insists that the surface pavement perform an efficient manifold service—comfort, appearance and ease in cleaning, but shall be primarily an ample protective covering for the base. Satisfactory wearing surfaces for either economy or expediency have been practically reduced in many cities to two types, dressed granite block and asphalt. We have shown in the recent investigation that the disintegration of base concrete in two selected cases was due to the failure of the wearing surfaces. Every pot hole, depression or minor break not only is a potential menace but if allowed to go on without being repaired must eventually cause damage to the foundation from the impact of dropping loads. It is obvious, then, that the wearing surface should be smooth and substantial; it will give service and function properly only in direct ratio to the attention it receives from the maintenance organization. Dressed granite block has shown most satisfactory results in serving modern requirements in this city and has afforded a sufficiently smooth running surface. It has been expedient and economical to use this type of surface in Philadelphia because of the large mileage of streets already covered with granite block on gravel base, permitting the redressing of selected block. With a high resistance to displacement and greater adaptability to uniform distribution of loads, we have found very little evidence of base disintegration under block, except that attributed to poor subgrade or in ditches and cuts replaced some time after repaving. We endeavor to repave in kind—block for block—but expediency also requires that in repaving programs a balance be maintained between block and asphalt, including sections of our main-traveled thoroughfares. Asphalt, although used exclusively on new paving operations, is less hardy than block and shows more quickly the devastating effect of heavy loads. In a greater measure than is the case with granite block, the life of the wearing surface is dependent upon prompt maintenance repairs, although in our investigation we found only two instances where disintegration or possible neglect in making prompt repair was the direct cause of shattering of base. But observation alone, irrespective of the type of wearing surface, will demonstrate the futility of preserving base without periodic maintenance patrol.

Use Reinforcement.—In the above survey we have endeavored to outline what appear to be the major causes for base failures, endeavoring to suggest the corrective measures that might be applied. It seems to be generally recognized, however, that a change may have to be effected in the character of concrete base or improved methods employed to guarantee against failure during normal life. The principal suggestions so far brought forward are an increase of two inches and upwards over the commonly accepted depth of six inches, strengthening of the mix and the resort to reinforcement. The last idea will not find favor in many municipalities, at least not until the day arrives when city streets are laid out boulevard fashion permitting the placing of all subsurface structures in the footways or allocated unpaved areas in the roadways. To a limited extent, placing of reinforcement in base foundation should receive serious consideration. The tendency of track structures, particularly intersection crossings, turnouts and switches, to cause paving defects and consequent irreparable damage to base concrete would seem to warrant in special cases of this kind the use of reinforcing material, not only to protect the base itself but the substructures passing un-

derneath; otherwise, the necessity for intermittent opening up of street paving and the difficulty of replacement from the engineering standpoint does not appear to justify the increased cost of this type of construction. Not one of the eleven cities heretofore mentioned has adopted reinforcement in city street paving. The use of reinforcement may, however, shortly become desirable in the replacement of concrete over service cuts and ditches unless methods now employed to guarantee stability of the backfill prove to be more satisfactory than is now the case.

Several Specifications.—A richer mix, at increased initial cost, may indicate the trend of thought in some cities, as the following data show:

MIX PROPORTIONS.

1:8	Buffalo
1:2:3 to 1:3:6	Chicago
1:6	Cleveland
1:2:4 to 1:3:6	New York
1:2:3	Pittsburgh
1:2.5:4.5 (stone or gravel) and 1:2.5:4 (slag)	Detroit

Note: Compiled data quoted in this paper are subject to correction due to possible recent changes in specifications.

A survey of these eleven cities shows that to date only two, Buffalo and Detroit, have incorporated as a requirement of their specifications eight-inch concrete base; New York, Philadelphia, Pittsburgh, Washington and Newark still maintain the six-inch depth; Baltimore, four, five or six; Boston, Chicago, Cleveland have specified no depth, evidently with the thought of meeting special or variable conditions. Nevertheless there is a growing disposition to believe that increased depth of base is the solution of the problem. It may or may not be. But in the belief that we must provide extra depth of base if we are to have future security in the soundness of our foundation paving, Philadelphia completed two major repaving projects in 1926, using eight-inch concrete base. One was in the water front section where traffic is not only congested but heavy, and the other on a heavily travelled truck, touring car and bus route. Experience has demonstrated, granting that all possible care has been taken in the preparation and placing of 6-inch foundation, that failures do occur. An increase in the factor of safety is inevitable and for that reason we believe we were fully justified in absorbing the additional cost on these operations.

As against the theories are the possibilities of improvements in the methods which may permit us to maintain a foundation of six-inch depth and one that will meet the test of heavy-duty traffic.

The Cost of Extra Thickness.—Any new proposition, involving other than minor changes in specifications, adds to capital expenditure per square yard. A mere increase of two inches in depth of 1:3.6 concrete on a city street, twenty-six feet in width between curbs will, at a conservative estimate add $10,000 per mile to the initial cost. Would a portion of this added cost utilized for new mechanical methods in the placement of base achieve the results we are looking for at less cost? Recently Philadelphia contracted for base paving of standard 1:3.6 mix, including a special mechanically applied surface treatment, producing an indented face for an asphalt wearing surface. In addition to ridging or corrugating the surface of the concrete the method employed apparently "squeezed out" the excess water in the carrying vehicle. A 3½-inch square by 7-inch prism of this concrete was sent to the laboratory and substantiated the claim of a strengthening increment, incidental to the process, by developing a unit compressive strength of 2430 pounds, 62 per cent over the usually accepted figure of 1500 pounds per square inch for this mix. We are not selling this idea; the thought merely occurs that this field of research is still open.

Have we secured the best results with the means at our command? Would the increased cost of additional depth of concrete or stronger mix or reinforcement be absorbed or approached by greater care exercised in preliminary preparation, more rigid adherence to specifications, the reduction to a minimum of the vagaries of human judgment, less speed and better quality in the making and placing of six-inch base? The same elements of uncertainty may and probably will exist no matter what new type of construction is advocated and used, whereas conscientious effort and a betterment in methods both in construction and maintenance may be the measure of the most efficient kind of production at less extra cost and without radical changes.

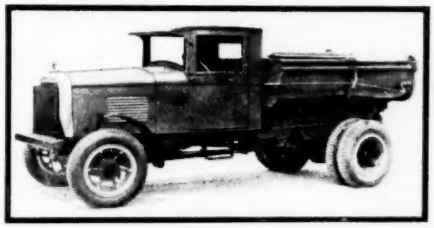
The problem deserves and will receive, no doubt, serious study. If and when changes in type of construction become a part of standard specifications, it would seem that the exercise of good judgment will be essential and necessary as special conditions arise, or when, in the opinion of the engineer, present and anticipated traffic demands are not a part of the consideration of initial costs.

On the other hand we face abnormal conditions in modern transportation, and no one can foresee where the limitations of weight, volume and speed will end. The idea of first cost must be left out of the picture, and we will perforce accept necessary changes in design and construction, building for the factor of resistance upon the same principles as in bridge work and as economically as we may. The end will justify the means.—Public Works.

Indiana Announces New Model Pavers' Truck

The demand for a six-cylinder two seven-bag batch paving contractor's truck has resulted in the design of the Indiana model "615A" Road Builder, just announced by the Indiana Truck Corporation of Marion, Ind. The six-cylinder engine with which it is powered gives smoother power, eliminates vibration, as well as permits higher speed, it is claimed. Chassis of this type in road building work are used principally where longer hauls are required and fewer stops. The total weight is 6,900 lbs. The Model 615-A six-cylinder Road Builder will be furnished with a 60-72 cu. ft. dump body, which is the right capacity for two 7-bag batches, 1:2:3 mix, and also two 6-bag batches, 1:2:4 mix, or two 6-bag batches, 1:2:3½ mix, when the cement is carried in sacks on top of the sand and stone.

This truck has a wheelbase of 136 in. The loading space is ample for the



The New 6-Cylinder Road-Builder Truck Built by the Indiana Truck Corporation

duty required, since the length back of the seat is 7 ft. 4 in., length from seat to center of the rear axle is 4 ft. 9½ in., and the width of the frame is 34 in. Front wheels are equipped with 32x6-in. pneumatic cord tires, while the rear wheels carry 34x7-in. dual pneumatic cords. Turning radius is 24 ft.

The engine is of six cylinders, 3⅜-in. bore, and 5-in. stroke, and of the valve-in-head type. Plain tube 1¼-in. carburetor and manifold hot spot handle the fuel, while ignition is supplied by high tension magneto driven from the pump shaft. Transmission is of the four-speed selective type, mounted in unit with the motor, with a low gear reduction of 5½ to 1. The clutch is of the dry plate type, Raybestos against steel. These and other interesting points are covered by specifications that may be secured from the manufacturer.

The same manufacturer has brought out a similar job known as the Model 111-A Road Builder. It is powered with a four-cylinder motor and equipped with a 1½ cu. yd. dump body (41 cu. ft.), and hydraulic underbody hoist. End gate is double-acting. This smaller truck has a turning radius of 20 ft. The general specifications of this model are otherwise generally the same.

Flow Tests from Hydrants

Pitot Tube Method Described in Paper Before California Section American W. W. Assoc.

By R. C. STANGE
Engineer, National Board Fire Underwriters

THE equipment necessary consists of a hydrant cap tapped out to take a pressure gauge, four Pitot blades, four 50 lb. gauges and a 200 lb. gauge. The Pitot tube ordinarily used is a straight blade about 4 in. long, threaded to connect to a piece of ¼ in. brass pipe a few inches long, on the other end of which is screwed the 50 lb. gauge by which the velocity of discharge is determined; a union may be used to allow a change in the relative position of Pitot blade and gauge dial.

The gauge best suited for the purpose is graduated in half pounds, from 0 to 50 lb., which may easily be read to the nearest quarter pound. Gauges of such a small maximum reading should be calibrated by means of a weight tester or reliable test gauge before being used, as they are more sensitive to rough handling than gauges designed for higher pressures. Gauges without pin at zero are recommended.

How Test Is Made.—In making flow tests, it is preferable to use 2½ in. hose outlets rather than 4 or 4½ in. steamer connections, for the reason that in the latter the orifice is often not completely filled or the velocity of discharge is not uniform throughout the entire area. Neither of these disadvantages is so marked in the smaller outlets and may usually be ignored entirely. The area of no flow is almost always a segment of varying height in the bottom of the outlet; this height may be estimated by the observer by using the Pitot blade or a rule. In most cases the "hole" or area of no flow is fairly well defined and its proportion to the area of the entire outlet may be calculated. Where the pressure is insufficient to fill the outlet to the top, measurement of the depth of water flowing is sufficient to determine the discharge.

Velocity heads of from 2 to 20 lb. are desirable, as they are read with greater accuracy. For very low velocities an error in the gauge reading has a greater relative effect, and for high velocities there is likely to be much fluctuation. The observer will soon train himself to estimate an average velocity by moving the Pitot tube across the stream; ordinarily for 2½ in. outlets the center reading will be substantially the average.

Close to the sides of the outlet there is a retardation of flow, to take account of which a coefficient of discharge is applied to the theoretical quantity corresponding to the indicated velocity.

This coefficient has been determined for three makes of hydrants, with outlets of different sizes and with various velocities of discharge; the discharges as measured by Pitot tube at the outlet were compared with those determined by Venturi meter, pitometer and current meter.

In these experiments the coefficient of discharge varied from 0.85 to 0.96 with an average of 0.91; a coefficient of 0.90 was employed in computing the tables used by the National Board.

Determining Quantity Available.—The pressure in the mains before and during the test, is noted by a gauge attached to a hydrant which is preferably in the center of the group of hydrants opened. Knowing the loss of head due to ordinary consumption demands and the additional loss due to a measured flow from hydrants, the quantity available for any other given loss may be closely approximated.

The number of hydrants opened in an individual test depends largely upon the strength of the distribution system; in a well-gridironed system, four are ordinarily used. The object is to draw enough water to lower the pressure in the mains by 10 to 20 lb., which is sufficient to insure accuracy in estimates of flow available at low residual pressures. Rarely does the number need to exceed four, except in distribution systems of exceptional strength. The layout of the test, of course, varies according to the character of the system; particular attention should be paid to the location of the residual gauge in order that it may represent a true average pressure in the mains when the hydrants are open. One hydrant opened each way from the residual gauge is considered ideal.

Actual Fire Conditions Simulated.—Effort should be made to simulate actual fire conditions as much as possible; the ordinary fire department pumper is usually of 750 or 1,000 gal. a minute capacity and this is considered a reasonable flow per hydrant; with two hose outlets open, this quantity gives a gauge reading within the most accurate range. Larger flows may produce erroneous local friction losses.

For making flow tests, the California type hydrant in common use on the Pacific Coast is the hardest to handle; having the valve directly at the outlet, it is necessary to open the hydrant wide to produce as smooth a stream as possible. With high initial pressures, discharge readings too high for accurate measurement are obtained in this manner and there is in addition the danger of wetting down adjoining property from the spraying produced as the hydrant is first opened. The latter drawback can be reduced somewhat by using short pipes on the outlets, made by leading a 12 or 15 in. length of 2½ in. pipe to an ordinary hose coupling. In extreme cases it may be necessary to shut the gate-valve in the hydrant branch, open the hydrant outlets wide and then control the flow by means of the gate-valve. For all other standard makes of hydrants, the opening of the hydrant can be controlled to give the desired flow.

When Readings Should Be Taken.—Hydrants in the group are opened simultaneously and, as soon as the rate of flow is steady, as shown by the residual pressure gauge, a reading taken on each discharging outlet. Operators should be cautioned to shut down slowly as the flow of the group is greater than that drawn in the flushing of a single hydrant, with consequent greater water ram, unless these precautions are observed. Care should also be taken to keep the hydrants open long enough to allow the residual gauge to settle down to a steady reading, the initial drop in pressure as the hydrants are first opened will always be greater than when the surging has settled down and the flow has become steady.

With a definite drop in pressure thus obtained for a known quantity of water flowing, the quantity available at any residual pressure is readlily estimated by using the Hazen-Williams hydraulic slide rule. This method will answer for most tests but cannot be used where the assumed residual pressure would lower the hydraulic gradient below any high point of the main between the source of supply and the test. Approximate results may be obtained with an ordinary slide rule.

In analyzing results of tests, actual conditions prevailing at the time of a serious fire should be taken into consideration. For instance, an elevated tank of small capacity near the test will result in an unduly high rate of flow which cannot be maintained when the tank has been emptied. In cases of this kind the test is best run with the tank shut off.

Value of the Tests.—Tests should be made at representative points in the distribution system. Some should be made on the main arteries to determine their adequacy, and others on minor distributors to study local losses. Aside from their use as a direct measure of the water available for fire protection, the tests may be of value to the water works engineer in other respects. They indicate the presence of obstructions in the mains, such as closed valves and show the reduced carrying capacities of mains due to tuberculation or incrustation. As they show the effects of a known draft, they furnish data to calculate the effect of any demand and can profitably be employed in designing reinforcements to the distribution system.

Canadian Section Am. W. W. Assoc. to Meet in March.—The next meeting of the Canadian Section of the American Water Works Association will be held March 7 to 9 at London, Ont. A. U. Sanderson, Filtration Plant, Centre Island, Toronto, Ont., is Secretary.

How St. Louis, Mo., Maintains its Sewers and Cleans its Catchbasins

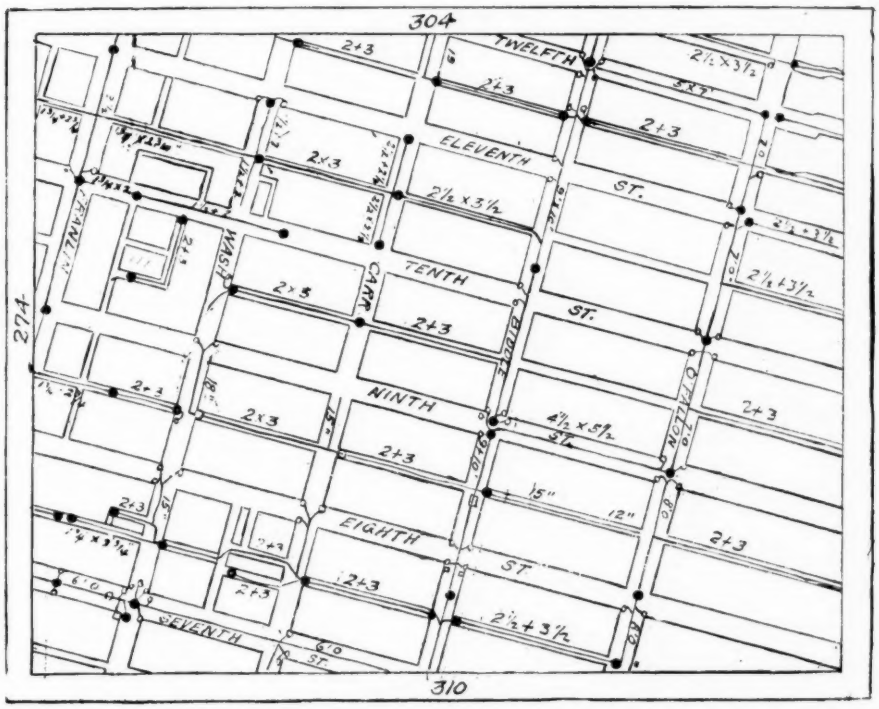
Handling Complaints—Concrete Inlets—Special Nozzle for Cleaning Trapped Inlets

By E. PAFFRATH
Assistant Sewer Commissioner, St. Louis, Mo.

IN ST. LOUIS we have the good fortune of being located on the west bank of the Mississippi River. This enables us to have a sewer system with a gravity flow, all sewage eventually emptying into the river.

We have a combined sanitary and storm water system. Our main lines or trunk lines have fairly good grades, and therefore require little or no maintenance as far as cleaning is concerned. However, many of these trunk lines are 50 and 60 years old and are beginning to show considerable wear, with a result that we have mapped out a program of reconstruction of these sewers.

Cleaning Districts.—The city is divided into eight cleaning districts. Each district has an office and a garage for storing trucks and equipment. These district offices are equipped with two phones, a police or fire alarm phone, and a Bell phone or business phone, so that all districts can be readily reached by the main office for the purpose of relaying complaints and other matter with which I think all sewer departments are familiar. While speaking of complaints I will discuss briefly the manner in which they are handled in regard to their record, etc.



The District Map. This Plan Is Represented on City Map by a Small Rectangle. The Map Is on a Scale of 1320 Ft. Equals 1 In.

Complaints.—Most all complaints are received at the main office. Upon the receipt of a complaint by telephone or otherwise, it is recorded in a record book, then it is immediately transmitted to the branch office located in the district from which the complaint originates. A complaint slip is then made out, which contains the number of the complaint, the name of the foreman and the nature of the complaint. This complaint slip is divided into two parts, the upper part contains the information that I have just mentioned and the lower half is reserved for the foreman's report. The foreman may not receive the complaint slip. If he receives it, he will, of course, return it with the proper notation, if not, this same information is sent in with his daily report, which arrives at the main office every morning, and is then entered on the complaint slip.

These slips are filed away in numerical order and kept in our files for three years, and after that time they are placed in a vault. These complaints as well as the details of the complaints are finally recorded in a large ledger in alphabetical order. This also shows the names of the men engaged in the work, as well as what has been done, making the record complete.

Law Suits.—We have occasion from time to time to refer to these complaints in regards to suits being brought against the city. In these cases we must go back two and three years. It is very apparent that a systematic record is an important feature in sewer maintenance.

District Organization.—Each district has one foreman. The number of men and trucks in these districts varies according to their location. In the industrial section we have more men than in the residential section.

We also carry one watchman in each district, who also performs the clerical duties in connection with that district, such as receiving complaints that may be phoned directly to the district office or from our main office, and also making out other reports as occasion may require.

City Map.—Each district office is provided with a complete record of the sewers in that particular district. The record is made up in the following manner: A section of the city map representing that district is in a frame 18 in. long and 18 in. wide, with a glass covering the map.

This map is divided into small squares 1½ in. long by 1¼ in. wide. Each square is numbered. There is a total of 592 squares covering the entire city.

When a foreman wishes to familiarize himself with the sewers in any location within his district, he refers to the map to ascertain the number of the square in which this location is found and then refers to a set of blue prints which are in a box fastened to the lower end of the frame.

These blue prints have a plan dimension 8 in. by 10 in. and which shows the sewers and the size and locations that are to be found within the limits of the little rectangle on the map.

We have found that this additional equipment in our various district offices has saved a great deal of time. It also gives the district man a better opportunity to become familiar with the sewers in his district, which is very essential if efficient work is desired.

In the main office there is a complete map of the city, divided into eight districts and the entire map again sub-

Precast Concrete Catchbasin Set Up. The Basin Can Be Made Trapped or Untrapped

divided into the smaller rectangles which I mentioned before. Below this map is also found a large case containing a copy of the plans covering the entire sewer system.

Additions and Changes.—When additions or changes have been made in the sewer system, the respective tracings are looked up, which cover the locations where these changes have been made. These tracings are corrected and new blue prints are made and sent out to the district or districts affected through such changes, as well as the record in the main office.

It is also sometimes found that a record may be in error. This occurs, especially in the older neighborhoods of the city, for as we all know, years ago the records were not kept as complete as they are now.

When the district man discovers such irregularities, he makes a complete investigation of the same and corrects his blue print accordingly, which he sends back into the main office so that the tracings can be corrected and new blue prints printed.

Small Sewers. — Our small sewers such as pipe lines cause us the most trouble of becoming blocked occasionally. This is also due to the fact that a lot of these pipe line sewers are very old.

Since many of these sewers have been constructed, the water-shed was greatly increased through the improvement of paved streets and alleys and thousands of houses being added, all of which overtaxed the sewers to the extent that they have become overcharged.

Many of these overcharged sewers have been relieved with relief sewers and many more are being relieved at the present time. We have had the good fortune of having passed a bond issue in St. Louis in which one of the items provides for the purpose of taking care of these conditions.

The Sewer System.—We have a total of about 1,100 miles of sewers, varying in size from 8 in. to 32 ft. in diameter, and varying in depth from 8 ft. to 50 to 60 ft., with one exception, that is the Mill Creek relief sewer, which has an average depth of about 90 ft. In connection with these sewers we have approximately 40,000 inlets and catch basins, both trapped and untrapped.

Sewer Cleaning.—In regards to sewer cleaning which practically is confined to the small sewers, I do not think that I could add to the method employed in this matter, with which I think you are all familiar.

We use ordinary tools and equipment, which consists of the fire hose, rotating nozzles, root cutters, flushing bags, sewer rods, etc., which are used in their respective place when occasion may require, besides the larger equipment such as derricks, air compressors and concrete mixers. However, the latter equipment is used mostly on sewer repairs.

Sewer Repairs. — The same would apply to sewer repairs. I think every sewer man in the country realizes that the average sewer repair job is an emergency job, usually due to a cave-in during or after a heavy downpour of rain. This condition, of course, applies only to the older sewers.

Owing to the extreme depth of some of our sewers, these repairs have often amounted to a great deal of money, on account of the large cavities or holes left in the street as a result of one of the old brick lines caving in.

The sewers are constructed of various materials, vitrified clay pipe, brick sewers, segment block and reinforced concrete sewers, with vitrified brick flow lines.

Trapped and Untrapped Inlets. — It has been customary during the past to construct untrapped inlets on storm water sewers, also along some sanitary sewers which engineers in the past thought had sufficient grade to carry the sewage off quickly enough so as not to throw off an offensive odor. However, this practice is being abandoned, for it has been found that it was necessary to reconstruct many of the untrapped inlets and trap them, to prevent bad odors from escaping from the sewer, with a result that all inlets now connected directly to the sewer are trapped, and inlets or catch basins connected to trapped inlets are untrapped.

The depth of a trapped inlet is 6 ft. and the depth of an untrapped inlet or catch basin is 4 ft. These are our standard depths in St. Louis for inlet construction, with a diameter of 2 ft. 10 in.

Standard Inlets.—Every city as a rule adopts a certain standard of inlet design. Therefore I will only discuss the St. Louis standard. All inlets have their intakes at the curb and have as a cover a concrete slab measuring 4 ft. by 4½ ft. by 5 in. thick. This also acts as part of the curb at that point. The opening in the top of the slab is 22 in. in diameter and the opening in the curb for intercepting the water off the street is 4 ft. by 6 in.

In front of the inlet is constructed a sump, the lower end or downward stream end has an abrupt rise and is constructed so as to turn the water into the opening. This standard has been adopted in a wide area surrounding St. Louis.

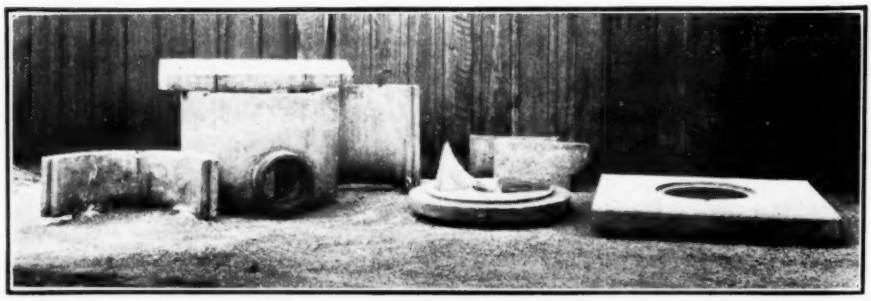
The trap in the trapped inlet consists of a 12-in. wye pipe. These wyes are inverted when they are installed and the upper part or straight end of the pipe sealed, the junction part of the pipe acting for the outlet for the inlet. I have submitted a blue print which will explain this more in detail than I could in this paper.

Concrete Inlets.—Since the high scale of wages paid to skilled labor, such as bricklayers, it was thought advisable to design a pre-cast sectional concrete inlet. However, the design of this inlet is the same as that of the brick inlet.

The sectional concrete inlet has many advantages, as follows: Cost of construction is about 40 per cent less than brick inlets. They can also be removed or salvaged in the event a street is widened. Another advantage is that they can be cast in advance and stored away, so that on a street job which is under contract and is ready for the sewer revision work, these inlets can be installed without delay.

I may mention at this time that in St. Louis the sewer department does all the sewer work in connection with streets under construction. This means that we must be careful at all times to cause no delay to the contractor.

I do not want to leave the impression that when I mention concrete inlets that we have stopped using brick inlets, for that is not the case. There are many places where concrete inlets cannot be used. Where electric conduits, gas pipes and other public utility property is encountered under ground,



Different Parts of Precast Concrete Catchbasin

a brick inlet is necessary. But there are still many places as one can easily judge, where these concrete inlets can be used to a great advantage.

This concrete inlet which I have designed for the City of St. Louis, but which like many other units of construction, has been found to be patentable; therefore it was necessary to take the necessary precaution of protecting the city against any future litigation.

Multiple Inlets.—We also have the multiple inlet. This inlet consists of the regular trapped inlet with a rectangular basin, constructed to one side of it and connected directly to the inlet. Our standard outlet pipe for the inlet is 12 in., but on multiple inlets this diameter is increased to 15 in. This is also the case where catchbasins are connected to trapped inlets.

Department Motorized.—Prior to 1923, inlet and catchbasin cleaning in St. Louis had been more of a problem than it is today. Prior to this time it was the custom in St. Louis to have hired teams. I believe I express the census of opinion in this meeting, when I say that hired teams in public service are a general nuisance.

This has been found to be the case in St. Louis, with the result that the sewer department today is entirely motorized. This gives us complete control over our transportation, which is not the case with hired teams. Our hand cleaning during the hired team period went as high as $3.50 per basin. After motorizing the department and increasing the efficiency of the men, this cost has been cut to $1.53 per basin.

Cost of inlet cleaning depends a great deal upon the length of the haul to the dump. I suppose that every city at some time or another is confronted with the proposition of a shortage of places to dispose of this material.

Some day other methods will have to be devised for the disposal of this material. So far, no serious thought has been given to that, yet it is very evident that the day will come when it will have to be solved. Just what the solution of it will be, I am not in a position to state at this time.

St. Louis is beginning to appreciate that efficient equipment is necessary in its sewer department.

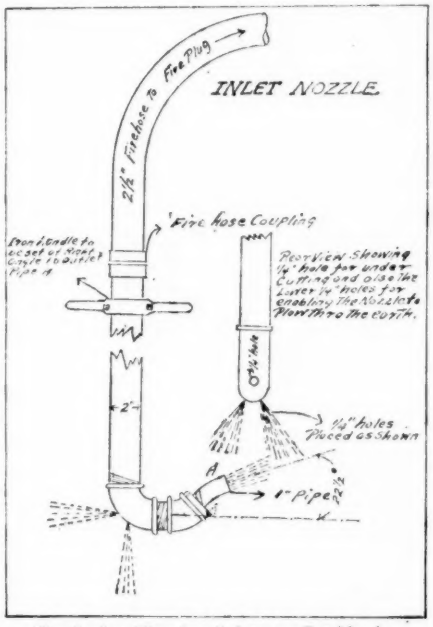
Eductors.—We have at the present time in St. Louis two eductors or inlet cleaning machines, and we have asked for another machine in this year's budget, which we have every reason to believe will be allowed. We intend to ask for additional machines in the future.

These eductors have been doing exceptionally good work. But we have some areas, especially in the industrial districts, where machine cleaning is not entirely satisfactory, owing to the nature of the material found in these inlets which necessitates a certain amount of hand cleaning.

The cost of our machine cleaning runs from $0.90 to $1.03 per basin. As I have mentioned before, this could be further reduced and probably will be in the near future when new locations are found for the disposal of dirt, cutting down the distance of transportation.

Falling Leaves.—During the fall when the leaves begin to fall, especially in the residential section of the city, we encounter a great deal of trouble, as probably all cities experience during this time of year.

Some people seem to think that when an inlet is located near their residence, that it was put there for the purpose of disposing of their leaves and rubbish, with a result that during this time of the year in those sections we have quite a number of blocked inlets.


INLET NOZZLE
2½" Firehose to Fire Plug
Fire hose Coupling
Iron Handle to accept at Street Cover to Outlet Pipe A
Rear View Showing ¼" holes par under Cutting and also the Lugs for enabling the Nozzle to Work into the earth.
2'-0"
1¼" holes Placed as Shown
A
1" Pipe

Nozzle for Cleaning Inlets or Catchbasins

Public Co-operation.—We have tried to cut down this expense by appealing to the people through the press, calling attention to the fact that these intakes are not built for that purpose and what it would mean to them if they would co-operate with the city in protecting this part of their public property. However, I cannot say that we have been very fortunate in this direction. The newspapers seem to be more interested in other matters pertaining to the municipality than in the efficiency feature of it. No doubt many of you have had the same experience.

Nozzle for Cleaning Inlets or Catchbasins.—We have also designed a nozzle for the cleaning of trapped inlets or catchbasins that are directly connected to our large sewers. This nozzle is about eight feet long and can be extended to any desired length by merely the addition of pipe. This nozzle is connected to a 2½-in. fire hose and then to the fire plug. This nozzle will flush the dirt through the trap into the sewer, thus saving the labor of taking the dirt out of the inlet and hauling it to the dump.

A test was made at Gasconade St. and Illinois Ave., where there are located four inlets which are never cleaned, because both streets are nothing but country roads, and these inlets are set back in the weeds. They were probably built years ago in connection with that sewer district, but the streets have never been improved. These inlets are of the regular dimensions, were filled with 5 ft. of dirt. After the water had been turned on, it took exactly 4½ minutes to dispose of the dirt in the inlet from the time that the water was turned on until it was turned off.

However, I do not recommend the use of this equipment except in such cases where the dry weather flow is sufficient and the sewer large enough to take care of the dirt.

Acknowledgment.—The foregoing is taken from a paper presented at the recent annual meeting of the International Association of Street Sanitation Officials.

Water Rates at Washington, D. C.

During the last fiscal year the water works in the District of Columbia were increased. The report of the operation of the Engineer Department of the District for the fiscal year ending June 30, 1927 summarizes the increase as follows:

The rate for domestic purposes shall be charged according to stories and front feet. On all tenements two stories high or less with front width of 16 ft. or less, $7.03 per annum in advance. For each additional front foot or fraction thereof greater than one-half, 44 ct. For each additional story or part thereof, one-third of the charges as computed above.

Business premises are rated according to their size, class, volume of business, and water facilities, and rate from $1.41 to $25. If the flat rate on business establishments reaches $25 or more the owner or occupant is required to install a water meter at his own expense.

A minimum rate of $6.36 will be charged against all consumers supplied with water through meters, which allows the use of 7,500 cu. ft. of water during the year, water used in excess thereof will be charged at the rate of 6 ct. per 100 cu. ft.

Feeding Garbage to Hogs.—The notes following are taken from Farmers Bulletin 1133, issued recently by the U. S. Department of Agriculture: Waste food products of more than 8,000,000 people are fed to hogs and fully 40,000,000 lb. of pork are thus produced and sold annually; a ton of municipal garbage may be expected to produce 40 lb. of live weight of hog; garbage used must be reasonably fresh and free from injurious foreign articles; it is better for the city to handle garbage collection and then dispose of garbage to the hog feeder. Long-time contracts with the feeder tend to produce best results.

Operation and Control of Rapid Sand Filters

General Discussion of Difficulties Encountered and Means of Overcoming Them Given in Paper Presented at First Annual Conference of Maryland Water and Sewage Plant Operators

By S. T. POWELL

Division Engineer, Maryland State Department of Health

Rapid sand filters, frequently termed mechanical or American filters, are employed widely for the purification of public water supplies. The distinguishing features of these systems are the relatively high rates of filtration and the pretreatment of the water with chemical coagulants. This type of purification system consists of two essential parts, namely, the coagulation and settling basin and the ulter units. The general design of the equipment has been fairly well standardized during the past twenty years and beyond certain specific construction details, all plants of this kind function in the same way.

The responsibility for the details of the construction of a system rests upon the designing and construction engineer. With the completion of the plant the responsibility for producing good water is transferred to the operator. It is this phase of the problem that the writer will discuss briefly. A filtration system may be designed and built with the greatest care, but may fail completely due to lack of intelligent control. On the contrary, a similar system that is not so well built may produce entirely satisfactory results by careful and conscientious operation. The basic principle of coagulation is essentially chemical, but it is not absolutely necessary that such work should be controlled by a chemist. Many filter plants are operated most efficiently by men who have no special training in this field. Satisfactory filter results may be obtained, however, only by intelligent operation based upon a fundamental knowledge of the process and a keen observation of the functioning of the various parts of the system.

Coagulation.—The main purpose of using chemicals in water filtration is to form an insoluble gelatinous substance that assists purification in two ways. It collects the suspended solids and removes them from the water by settling in the basin or it is carried to the filter beds and coats over the sand thereby assisting in the clarification process. Aluminum sulphate, ferrous sulphate and lime and other chemicals are employed for this purpose.

The chemicals are fed either in a dry state or as a solution. Filter efficiency depends largely upon proper control in feeding the coagulant. No definite scale of treatment satisfactory for all water supplies is possible. The chemical properties of different waters vary greatly and the quality of even the same water varies from season to season and frequently from day to day. Exact treatment may only be determined by careful observation, utilizing the experience gained in this manner for proper control.

Determining Proper Dose of Coagulant.—One of the most satisfactory methods for determining the proper doses of coagulant to be applied to the water is the so-called "jar treatment." Small samples of the untreated water are dosed with various amounts of the chemicals. The samples are stirred for a short time and then set aside and the rate of floc formation and the character of the coagulated material noted. Wherever possible, the jars should be placed so that the light will shine through the water. Careful observation will indicate the dosage of chemical to give the most satisfactory plant treatment. The control of many plants is carried on in this way and excellent results are obtained.

Some experienced operators adjust the chemical dosage by observation of the floc as the water flows to the filters. When the water contains very finely divided suspended matter termed by some operators "smoke," improper coagulation is indicated, while, if the floc appears to be suspended in clear water, good filtration is possible. Filter operators may acquire considerable experience in this respect by frequent observation of the treated water. The same condition may be noted equally well at night by submerging an electric light or flash light into the water or by directing a beam of light through a clear glass containing the treated water.

It is not only necessary to determine the proper amount of chemical to be applied to the water but it is equally important that the equipment for feeding the chemical functions satisfactorily. If the plant is equipped with a dry feed machine, the apparatus should be checked frequently to determine if it is properly calibrated. Clogging or stoppage described as "freezing" is the difficulty most frequently encountered.

Where liquid or solution feed of chemical is used, stoppage of the orifice that regulates the flow results often in improper treatment. Alum and other chemical solutions should be stirred frequently or preferably stirred continuously by mechanically operated paddles. Irregular plant operation may be traced more frequently to stratification of chemical solutions than to any other single fault. Chemical storage tanks and feeding devices should be cleaned out at intervals, since filter alum and other coagulants contain an appreciable amount of insoluble material that forms sludge which interferes with accurate doses of the chemicals.

Sedimentation Basins.—The purpose of sedimentation basins is to permit the removal of suspended material from the water prior to filtration, thereby reducing the load on the sand bed, lengthening the time between cleaning the units and affecting other incidental improvements in operation. The time between cleaning the basins should be governed entirely by the nature and amount of the accumulation in these tanks. Too frequent cleaning of basins results in an unwarranted waste of water, while too infrequent removal of these deposits may cause serious operating troubles. Sludge deposits should never be permitted to accumulate to the point where the water flowing through the basins will reentrain these solids and carry them to the filter. Where the deposited sludge in the settling basin contains much organic matter, difficulty may be experienced from redissolving of the floc, excessive gas formation, algae growths, tastes and odors and numerous other annoyances. Whenever any of these problems are encountered especially during warm weather, it is desirable to clean the basin if there is any appreciable amount of accumulated mud deposits.

Whenever sedimentation basins are emptied for cleaning, careful inspection should be made of the inlet and effluent control rates, leaks in walls or floor of the tanks and leaks in the chemical lines. Many lapses in improperly operated plants may be traced to leaks in chemical lines that discharge the solution in the basin at a considerable distance from the designed point of application, thereby losing the desired effect of mixing and reducing subsidence periods.

Filter Bed.—The most important part of a filter is the sand bed. Lack of attention to this portion of the system is certain to result soon or late in inefficient control. All sand beds should be drained and inspected each month and the operator should observe the bed during each washing and note any irregularity in the washing operation, since much may be learned concerning the condition of the units during this operation. Mud ball formation is probably the most baffling and annoying operating difficulty that is to be encountered in filter plant control. This

problem is present at all plants to a greater or less degree and no practical solution has yet been devised that will ensure complete elimination of the trouble. As the terms indicate, mud balls are solid areas of mud originating in small patches. These deposits grow in size and, if not controlled, completely cover the area of the bed, penetrating the entire depth of the filter.

Effective distribution of wash water, careful spacing of wash water troughs, good grades of sand and proper grading of the filter medium will do much to lessen these mud spots, but will not ensure complete elimination of the deposits. The maintenance of filter beds in proper condition in respect to mud ball formation is an operation problem and may be controlled largely in this way. Filters should be drained at regular intervals and inspected. Where patches of mud balls are noted on the surface of the bed, they should be removed by hand scraping. Where the mud balls have penetrated into the sand bed, it may be necessary to back wash the unit several times, scraping after each washing. In extreme cases, it is necessary to remove the upper layer of the sand bed or remove the entire bed and re-sand the units.

Mud ball formation is detrimental to efficient operation in many respects. These deposits are dense and almost entirely impervious to water. For this reason, little or no water passes through them, so that in order to maintain the desired rate through a given area, excessive rates must be maintained in the portion of the bed free from these accumulations. In addition to this failure, these deposits are a source of excessive bacterial pollution and impart a disagreeable taste to the filtered water.

Uneven distribution of wash water is in many cases responsible for poor filter performance. This trouble seldom occurs in new filters that have been properly designed, but may occur after a few years service. The trouble is caused by displacement of the gravel bed, blown off strainer heads, split pipes or other failures. An alert operator can observe the difficulty as soon as it happens by watching the distribution of the wash water during the back washing of the units. The condition is indicated by a spouting of wash water in the bed directly over the spot where the failure of the underdraining system has occurred.

Air-bound Filters. — Probably air binding of filters is responsible for more poor filter results than any other single cause, but it is likewise less understood by the individual operator. To understand this phenomenon, it is necessary to review briefly the theory of the solution of gases in water or other liquid. Oxygen, carbon-dioxide and other gases normally present in air dissolve in water. The amount of the gases that can be taken into solution depends upon the temperature of the liquid and the pressure on the gas and water. Considering for the time only the effect of temperature, the colder the water the greater the amount of gas that will dissolve in it. As the water is heated the gas (air) dissolved in it cannot remain in solution and is released.

When cold water enters a filtration system and passes through the filter bed, the temperature of the water is raised and the gas escapes into the sand bed. Since the water is flowing through the bed the released gas does not rise unless the volume becomes very great or the process is stopped, thus permitting the gas to pass upward through the filter medium. Trapping the gas in the filter medium causes a marked reduction in the rate of filtration and in extreme cases complete stoppage of the flow of water through the filter. The speaker has experienced cases of this kind where the filtration was stopped completely fifty minutes after the unit had been put into service.

When air-bound filters are encountered the entrained gas rises upward through the bed due to its buoyancy and in so doing perforates the bed. If the unit is put back into service again without washing, poor filtration will result since the filter bed is filled with small holes.

Where air binding is prevalent, short back washing periods at frequent intervals will greatly relieve the trouble. Air binding is more prevalent in winter than during the summer months, but may be encountered in some localities during warm weather. When the conditions occur during the latter period, it is traceable usually to prolific algae growths or similar micro-organisms, since these aquatic plants during their growth give off oxygen. Under some extreme conditions, the supersaturation of dissolved oxygen due to this cause may rise to 200 per cent.

Operation of Valves.—It is difficult to impress upon filter plant operators the importance of opening and closing all valves slowly. There is no single operation in the plant that should be carried out more carefully. Rapidly opening of the filter effluent valves results in a violent shock to the filter, causing holes and channels in the sand bed. This causes not only poor filter efficiency, but may permanently injure the bed by drawing the floc or even sand into the underdrainage system.

Sudden admission of wash water to the bed due to rapid opening of the wash water valve may do much damage to the underdrainage system. This is certain to result with shallow gravel beds and when the bed is composed of small sizes of stone or gravel. Especially is this true where the filter contains an appreciable quantity of entrained air in the bed. The writer has noted conditions of this kind where the gravel has been carried upward through the sand bed and strainer heads had been sheared from the laterals. Some designing engineers are eliminating these possibilities by installing slow opening valves. In large plants employing hydraulic or electrically driven valves, this condition may be easily controlled by the design of the valve operating mechanisms.

Controllers, Gauges and Similar Appurtenances. — Controllers, whether they are the simple ball float valve or more elaborate appliances, are installed to maintain relatively constant rates of flow of water through the filter. Sudden changes in filtration rates are detrimental to efficient operation. The majority of these equipments are fairly rugged and function satisfactorily with little adjustment. They should be inspected at intervals, however, and, when found to be out of adjustment or otherwise at fault, they should be overhauled.

Gauges and appliances equipped with recording charts should be kept in working order and the charts changed when necessary. Charts should never be used so that they overlap beyond their designed indicated period. Charts removed from the gauges should be dated and filed for future reference. The proper use of recording charts from correctly calibrated instruments is of much value for efficient plant operation.

Sight glasses or filtered water sight control appliances are of assistance in determining how the individual filter units are acting. There are many different designs of appurtenances of this kind. They all serve the same general purpose, namely, to indicate the relative filter efficiency as shown by the clearness of the filtered water. If these appliances are to serve the purpose for which they are intended, they should be kept clean at all times. It is desirable, also, that the glass container be replaced from time to time with new units, since even good glass in time is affected by the action of the water and the observed condition of the water is misleading due to the roughened appearance of the glass.

Sight glasses are employed at times as combination indicator glasses and for sampling devices. Where they serve this dual purpose, care should be used to clean them frequently since bacterial growth may occur in them with misleading results. Only high resistant glass (Pyrex) should be employed, since the alkalinity of the water is materially affected due to the solubility of the sodium salts in ordinary glass. Care should be taken especially in this respect, if the samples drawn from these glasses are for the determination of hydrogen-ion concentration of the water.

Analytical Tests.—No plant can be operated efficiently and economically without frequent testing of the raw and treated water and control of the system by means of these analytical data. The frequency of the tests and the individual analytical determinations should

depend upon the size of the plant, the kind of raw water treated and the type of system employed. It is difficult to generalize as to the specific determination that should be carried on in routine practice for all water supplies. The following information, however, is essential for the intelligent control of all plants:

Total alkalinity,
Turbidity,
Hydrogen-ion concentration,
Temperature (air and water),
Volume of water treated,
Amount of chemicals used.

It is of great importance also that the operator keep a diary of conditions relating to the operation. Such information, if conscientiously recorded, is frequently of much importance in the interpretation of results and assists materially in allocating the cause or causes of faulty control and poor operating results.

General Cleanliness of the Plant.—The efficiency of control of a water purification system and the interest of the operator may be judged largely by the general cleanliness of the ground about the property. Water is a food product and its purification should be subject to the same general sanitary requirements in preparing it for human consumption as for any other food.

Disinfection of New Mains

Methods of Sterilization Described in Paper Presented Before Florida Section of American Water Works Association

By CHARLES H. EASTWOOD
Wallace & Tiernan Co., Newark, N. J.

Unquestionably pollution, sometimes of the grossest nature, both avoidable and unavoidable, occurs in new mains, during the process of laying, and even the most uninformed of contractors and operators are sufficiently aware of this fact to carry out flushing of mains before putting them into service.

Flushing Not Enough.—While this simple flushing is of material benefit, it does not begin to go far enough. Most of us are familiar with the story of the superintendent who, on investigating the inability to close a valve, discovered that its operation was impaired by the presence of an old shoe, presumably thrown into or left in the trench by a laborer, and which subsequently found its way into the main. The mere flushing of mains may serve to remove old shoes, mud and dirt of construction, but it will not do much towards removing bacterial contamination that undoubtedly has been introduced during the time the pipe has been exposed before and during laying.

Disinfection With Chloride of Lime.—A popular practice is to introduce a small amount of calcium hypochlorite (chloride of lime), roughly an ounce to each joint of pipe, into the pipe as it is laid. When the completed section has been connected up, the section is filled with water and this water is allowed to remain in the pipe overnight. Other than the relative instability of the calcium hypochlorite and the consequent inability to determine the actual presence of available chlorine in anything like constant amounts, there are no objections to this method.

With the almost universal practice of chlorination of water supplies and the availibility of liquid chlorine, water superintendents have more and more shown a desire to use liquid chlorine for sterilization of new mains. Unquestionably it presents the surest means of achieving the result. Provided some simple, cheap method of introducing it into the main is devised, the operation becomes one of simple routine and is associated with the laying of new mains almost as unconsciously as is the actual digging of the trench.

Sterilization With Liquid Chlorine.—Almost every superintendent is capable of improvising a connection from the auxiliary tank valve, through a standard corporation cock, into the main. The only problem presenting itself is the extreme corrosive nature of the gas and the need for using connections that will not leak gas, either when first made or later when exposed to the influence of the corrosive effects of the chlorine.

Commercial forms of chlorine control equipment are entirely adapted to the purpose and where duplicate units of the relatively portable type are available at the water works, the problem no longer exists, as it is merely a question of transporting these to the desired point of application.

Where such units are not available a simple piece of equipment may be improvised from a standard connection into a main, such as is used on the smaller types of solution feed chlorine control equipment. This consists of an ordinary quarter inch gate valve fitted with a stuffing box and through which a small silver tube will slide. When desiring to disinfect a newly laid section of main the procedure resolves itself into several simple operations, as follows: The section of pipe should be flushed out thoroughly to remove all dirt, etc. Next tap the main and insert the connection with the silver tube withdrawn and the valve closed. Connect the silver tube through the medium of quarter inch rubber hose directly to the usual auxiliary tank valve on the standard chlorine cylinder. Care should be taken at this point to ensure all connections being gas tight. A little difficulty may be experienced in making the connection at the valve, but, if a valve is retained especially for this purpose, a permanent connection can be made by removing part of the union connection and litharging the joint.

Allow water to enter the section of the main to be disinfected at the minimum possible pressure. Turn on the gas, open the small gate valve and push the silver tube into the main.

It is well to bear in mind that, while we have the pressure of the gas in the cylinder to overcome the pressure in the main, any back pressure due to the pressure of water in the main is reflected back on the gas line and connections. It is advisable to keep this at a minimum.

Chlorine Dosage.—Ordinary practice entails a chlorine dosage of from 10 to 20 p.p.m., roughly 80 to 160 lb. of chlorine per million gallons of water.

This means that the water should be allowed to flow freely from the end of the section being sterilized until such time as it shows a heavy orange red color to the ortho-tolidine test, at this end of the pipe.

The silver tube can be withdrawn, the valve closed and the gas cut off. The closing of the valve and the cutting off of the gas should be done as nearly simultaneously as possible to avoid the building up of excessive gas pressure in the hose line or allowing water to get back to the cylinder valve. The valve is removed and the hole is plugged.

The heavy chlorinated water should be allowed to stand in the main for several hours and the main subsequently thoroughly flushed with fresh water to remove all excess chlorine.

Innumerable improvements in equipment and technique, ranging all the way from the simple addition of a standard diffusor and check valve to the use of standard solution feed equipment, present themselves to those familiar with chlorine gas control and chlorine gas control apparatus. Personally I should much prefer to amplify the method outlined through the use of a standard direct gas feed diffusor and chlorine check valve with the connections made through copper pipe and the usual union connection properly packed with gaskets. This means a larger investment, however, and would only be justified where there is considerable new main to be laid.

No accurate control of the chlorine dosage is possible or necessary with this method. The object is to put in chlorine and lots of it. As the cost of the gas is relatively small and the excess chlorine is subsequently removed by flushing the main, anything other than rough ortho-tolidine control is superfluous.

Typhoid Fever Rates 1910-1925—Of the 77 large cities in the United States, 30 had typhoid rates below two per 100,000 in 1925, while only two cities had rates over 20. Fifteen years ago, out of a similiar group of 51 cities not one had a rate below two and 17 had rates over 20.

Water Works Cost Accounting

Simplicity of Mechanics of Cost Accounting Pointed Out in Paper Before Central States Section Am. W. W. Assoc.

By PAUL M. KYDD
Bureau of Governmental Research, Pittsburgh, Pa.

THERE is no mystery about cost accounting. It is the measuring of the results of operation and the recording of the use of labor, materials and supplies, translated into the common terms of dollars, and set down in such a way as to make the results possible of interpretation. Its ultimate purpose is to show the way toward the saving of money.

I do not believe that anyone will question the need of cost data in a water works, so I will pass that by. What I would like to bring out in this paper is that while it is fine if one is able to have a cost accounting staff assembled in a bureau, the absence of such a staff does not necessarily mean that the water works must be without cost information. I shall not dicuss the reason why central accounting bureaus are not always possible. What I would like to stress is that it is possible to devise a cost accounting system that can be handled by the operating force of the water works with the aid of a few clerks.

Source of Basic Cost Information.—In the first instance, regardless of what system is used, or where the data are assembled, the basic cost information must come from the operating section where the labor, materials or supplies are used. This information is obtained by time cards for each individual and by a statement showing the use of materials and supplies. These elements of cost can be distributed by function in each operating section by its regular force. This may sound complicated, but when you really get down to it, it is very simple. It calls for a system of forms with explicit directions and definitions, and the insistence of the management that the records be kept. The forms should have the functions on which the management desires cost information listed on the left hand side of the sheet under the separate headings of Operation, Maintenance, Replacements or Betterments, and Additions. On the remainder of the sheet columns will be provided for the cost figures. The number of columns will depend entirely on how your funds are provided and how you desire to break down your cost figures. For example, if you were operating on a budget that provides your funds in separate accounts for labor, materials and supplies, you would provide a column for each of these items. You would add also a column in which to enter the work done by borrowed labor, that is labor furnished by one division to another, and one in which you would credit the function for work done by it for other sections.

Distribution of Cost Items.—The distribution of the cost items is purely mechanical and can be done by any clerk, once you work out the definitions for operation, maintenance, replacements or betterments, and additions. The definition of operation is so simple that it can cause no confusion. Determining whether an item is a maintenance or replacement charge will be troublesome, and so I suggest the following procedure. Any item of less than a given amount, say $100 exclusive of labor, will be charged to maintenance. For all items of over $100, employees should be instructed to telephone to some one designated person, who is qualified to apply the old yardstick of, "Does it add to the value, length of life or capacity of the plant?" Having one person making the decisions will also be helpful in keeping your valuation figures accurate, inasmuch as the decisions will tend to be uniform. The definition of additions is so simple that it can cause no confusion. The forms to which I have just been referring we will call Group 1, and on them we have entered the essential data for determining your functional cost.

Recording Operating Results.—Another set of forms, which we will call Group 2, is necessary for the recording of the results of operation. By setting up these forms in such a way that the items or functions correspond with those on which you have recorded the elements of cost, it is very simple to take off the results in such a way that they are readily interpreted. For example, if on Group 1 you have kept the cost of operating engines No. 1, No. 2 and No. 3, and on Group 2 you have recorded the gallons pumped by engines No. 1, No. 2 and No. 3, you can readily see that you have the cost of pumping a gallon of water by each engine.

The headings under which entries can be made on the form of Group 2 can be as detailed or as general as you desire, as long as you keep the items uniform with those on Group 1. All of the entries on both Groups 1 and 2 may easily be made by your regular employees.

Job Cost Data.—So much for the cost data by function. There are places where you will require cost data by job rather than by function. This will be true particularly in the distribution section, where the major part of the work is pipe laying. In cases of this sort the procedure is identical with the distribution of cost by function, except that the forms are designed to record the distribution by job instead of by function. By giving each job a serial number it is possible by this procedure to place before the executives periodically a statement showing the total cost of each job to date, together with the amount of work done and its relationship to the total. These data can then be readily distributed by function, if this information is needed for budget purposes.

Use of Cost Data.—When I speak of having the cost distributed in the operating sections, the question naturally arises, do you mean all operating sections? Let me answer that in this way. The ultimate purpose of gathering cost data is the saving of money. The men who are in actual control of each operation are the ones who are in a position to save money. Therefore my suggestion is to study your organization and determine from its working just which men are in actual control of the operation, and concentrate the cost data under them. I do not mean that these men should be the only ones who should have access to the cost information. For example, if you have five pumping stations operating as a division under supervisor of pumping stations, I would have the chief engineer of each pumping station, or a clerk under him, distribute the elements of cost for his own station. A copy of the distribution sheet would be sent from each of the five stations to the office of the pumping station superintendent, in whose office they would be summarized. The summary of the results of operation together with related cost elements would then be sent to the managing engineer of the water works. In other words, give each executive such cost information as he needs for intelligent administrative control and in such a manner that he can use it.

The proposed system has one outstanding advantage over any other system and one outstanding weakness. It may be well to mention these. The advantage in this system is that it places the cost information in the hands of those who are in position to actually affect the saving of money, and further it has a tendency to make them conscious of the cost element of their operations, due to the fact that they themselves are responsible for compiling the figures. The weakness is that a system of this sort is dependent upon the action of so many that it is very easy through carelessness to let it break down and drift into oblivion. This weakness need not be serious if the head of the works is on his job and is a real administrator, for if he insists upon receiving complete cost reports each month, the system cannot break.

$4,000,000 of Sanitation Bonds Voted in Ohio.—At the November election bond issues aggregating about $4,000,000 were voted by cities and towns for water supply and sewerage improvements. Three villages that had no public water supplies voted to install works. These were Antwerp, $35,000; Mogadore, $137,730, and Yellow Springs, $52,000.

Street Cuts

How Problem Is Handled at St. Louis Told in Paper at Convention International Association Street Sanitation Officials

By ROBERT B. BROOKS
Director of Streets and Sewers, St. Louis, Mo.

IN 1927 the City of St. Louis issued 12,060 permits for excavations in our streets. These excavations ranged from an ordinary 2 by 4 ft. plumber's cut in our pavement to the laying of a gas main two miles long in a major street.

In studying the subject of utility excavations, it was expedient to find out the practice of making service cuts in the pavement in other cities. The officials of every large city in the United States, from San Francisco to New York, and from New Orleans to Detroit, were generous in their response to our questions about service cuts. All these city officials were unanimous in expressing the general opinion that service cuts constitute a very serious problem in street paving.

A Potential Accident Hazard. — As you all know, when the original pavement is cut through for any purpose whatsoever, it constitutes first of all while being made, a potential accident hazard. When earth is taken from its original position, it swells, from a practical standpoint. Roughly speaking, this swelling is from 10 to 12 per cent.

When backfilled in the excavation, the general procedure over the country is to shovel this dirt in thin layers of from 3 to 6 in., tamping each layer by hand. In some cases water puddles remain. Later a temporary filling is made.

In past years in St. Louis this temporary filling consisted of 4 in. of sand, then a layer of paving brick laid on edge on the sand. Service cuts up to this point are maintained by the party making the opening. The street commissioner then decides on a maintenance period for the cut, not to exceed one year.

Mother Nature has a way of starting a process of further settlement. When depressions occur the party making the excavation is notified to make immediate repairs.

Everyone here realizes what even a small depression in the street does to traffic. Drive along any street, suddenly hit a depression of even 2 or 3 in. and there is a possibility of being thrown against the top of the car and losing control. If a small depression suddenly looms ahead of you when driving, the most natural thing in the world is to swerve suddenly to avoid the depression. If the surface of the street is covered with a greasy scum or moisture mingled with oil drippings and dirt, there is an excellent chance of skidding.

Nature's process of final settlement takes over one year. Thus, with our 12,060 excavation permits issued in 1927 and 13,200 in 1926, we are confronted with 25,260 places in St. Louis which must receive constant attention. This condition is true in every other large city, and the smaller cities in proportion.

On the other hand, every time an excavation permit is issued for a steam line, refrigerating line, gas main or service cut of any description, it means either a new dwelling or that the service to a building already constructed is being improved. It is a sign of progress.

How Problem Is Handled in London. —Whenever the original pavement of the street is disturbed, it can never be replaced to exactly its original condition. The ideal condition would be to have all of these services for buildings and yet not make excavations in the street. This condition obtains in the City of London. The section from the property line to the curb line is reserved for the city's use in the downtown district. This area has excavation as a long underground tunnel. When a connection is desired, it is comparatively a simple matter for the utility affected to send its workmen into this open tunnel and make the connection without disturbing the street pavement, as all water mains, sewers and all public utilities are constructed on brackets in this tunnel.

There is no city in the United States so fortunately situated, to my knowledge. In St. Louis, in new subdivisions the water and gas mains and utility conduits have, by permission of the Board of Public Service, been laid in the space between the sidewalk and the street curb instead of the roadway. This of course eliminates the possibility of depressions in the street as no excavation for service connection to the building is made in the street paving, but in the sidewalk space.

Use of Quick-Setting Cement.—The utility companies in St. Louis have, in the past two years, cooperated with us by using a quick-setting cement in all concrete structures in the downtown congested district. By the use of this quick-setting cement we have been able to remove barricades and accident hazards from ten days to two weeks sooner than when ordinary portland cement was used. All parties excavating in our congested district are required to work every day including Sundays and holidays, and sometimes at night, in order to close the excavation as quickly as possible.

We know that hand tamping of thin layers of earth is unsatisfactory on account of the human element. A man is not a machine and it is not possible to pick up a tamper and drive it home with the same force at 5 o'clock in the afternoon as it was at 5 in the morning. Many times you have seen a laborer using a tamper, when a foreman is not looking slide his hands up and down on the handle of the tamper without raising it a fraction of an inch.

Use of Air Tampers.—A hand tamper consists of a rammer weighing not less than 20 lbs. At our suggestion public utility companies in St. Louis have been using air tampers. The results have been not only more satisfactory than hand tamping, but a money saving has been effected.

Our department has under consideration at present a proposed change in the existing ordinance, requiring all parties making excavations for any purpose to use air tampers in the compression of dirt in backfilling the trenches. Under tests we have found that the average hand tamped trench gets only about 70 per cent of the earth returned to the excavation, and that with air tampers about 90 per cent of earth excavated can be returned to the trench.

Depressions in excavations for mains and conduit extensions where air tamping has been used, are reduced to a point where they rarely occur. The depressions in small service cuts are more numerous, and it is with these in mind that our department is considering the use of air tampers in all cases.

Those companies making many cuts would find it advantageous to have their own air compressors. Many plumbers would find it uneconomical. In case the party making an excavation is not equipped to backfill with pneumatic tampers, the street department should furnish service for the backfilling at a price based on the cost of the particular work done, which should include depreciation on the equipment as well as overhead of the department.

When a backfill has been air tamped up to the subgrade, the concrete base should be trimmed back at least 6 in. behind the line of excavation and a new base constructed. Then the wearing surface should be applied at least 2 in. behind this line so as to eliminate as far as possible the possibility of a depression cracking off the pavement on the lines of the excavation should it settle further.

The public utility companies are willing to cooperate on the method of pneumatic tamping, after being sold on the reduction of costs effected. The plumbing companies are against it because they believe it will mean less work for them should the city make the backfills. A program of education is necessary to sell them and the general public before an enforcing ordinance can be passed on this point.

Utility excavations in our streets are a sign of progress. They must be treated as individual problems so as not to constitute a potential accident hazard. The best way to accomplish this where new utility mains are to be laid, is to place them in that space between the sidewalk and the curb instead of in the roadway.